MODEL 43C Trace Level

PULSED FLUORESCENCE SO_2 ANALYZER

INSTRUCTION MANUAL
P/N 13399

CE

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The 220V option complies with 89/336/EEC directive for electromagnetic compatibility.

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CHAPTER 1
INTRODUCTION

The Model 43C Trace Level pulsed fluorescence SO_2 analyzer combines proven detection technology, easy to use menu-driven software, and advanced diagnostics to offer unsurpassed flexibility and reliability. The Model 43C Trace Level has the following features:

- Multi-line alphanumeric display
- Menu-driven software
- Field programmable ranges
- Dual range mode
- Autorange mode
- Multiple analog outputs
- High sensitivity
- Fast response time
- Linearity through all ranges
- Internal sample pump
- Totally self contained
- Insensitive to change in flow and temperature

Thermo Environmental Instruments is pleased to supply this pulsed fluorescence analyzer. We are committed to the manufacture of instruments exhibiting high standards of performance and workmanship. Service personnel are available for assistance with any questions or problems that may arise in the use of this analyzer.

PRINCIPLE OF OPERATION

The Model 43C Trace Level is based on the principle that SO_2 molecules absorb ultraviolet (UV) light and become excited at one wavelength, then decay to a lower energy state emitting UV light at a different wavelength. Specifically,

$$SO_2 + h\nu_1 \rightarrow SO_2^* \rightarrow SO_2 + h\nu_2$$

The sample is drawn into the Model 43C Trace Level through the **SAMPLE** bulkhead, as shown in Figure 1-1. The sample flows through a hydrocarbon "kicker," which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO_2 molecules pass through the hydrocarbon "kicker" unaffected.

The sample flows into the fluorescence chamber, where pulsating UV light excites the SO_2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains eight selective mirrors that reflect only the wavelengths which excite SO_2 molecules.

As the excited SO_2 molecules decay to lower energy states they emit UV light that is proportional to the SO_2 concentration. The bandpass filter allows only the wavelengths emitted by the excited SO_2 molecules to reach the photomultiplier tube (PMT). The PMT detects the UV light emission from the decaying SO_2 molecules. The photodetector, located at the back of the fluorescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light.

The sample then flows through a flow sensor, a capillary, and the shell side of the hydrocarbon "kicker." The Model 43C Trace Level outputs the SO_2 concentration to the front panel display and the analog outputs.

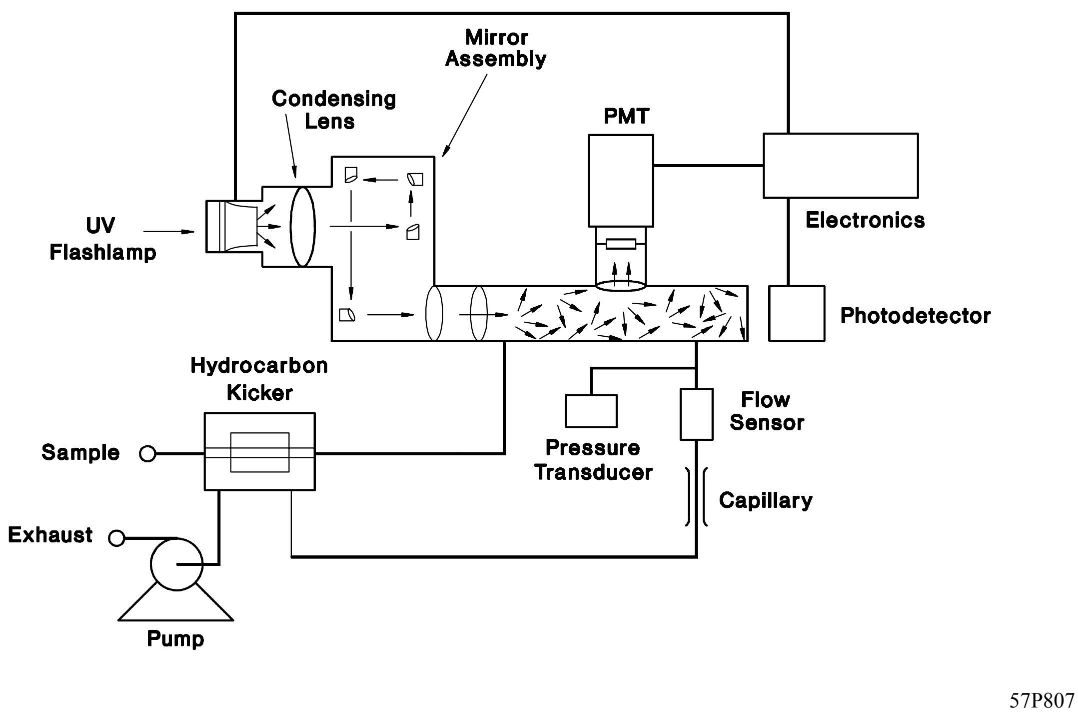


Figure 1-1. Model 43C Trace Level Flow Schematic

SPECIFICATIONS

Preset ranges	0-10, 20, 50, 100, 200, 500, and 1000 ppb 0-20, 50, 100, 200, 500, 1000, and 2000 $\mu g/m^3$
Custom ranges	0-10 to 1000 ppb 0-20 to 2000 $\mu g/m^3$
Zero noise	0.1 ppb RMS (10 sec avg. time) 0.05 ppb RMS (60 sec avg. time) 0.03 ppb RMS (300 sec avg. time)
Lower detectable limit	0.2 ppb (10 sec avg. time) 0.10 ppb (60 sec avg. time) 0.06 ppb (300 sec avg. time)
Zero drift	less than 0.2 ppb per day
Span drift	± 1% per week
Response time	80 sec (10 sec avg. time) 110 sec (60 sec avg. time) 320 sec (300 sec avg. time)
Linearity	± 1% of fullscale
Sample flow rate	0.5 liters/min. (standard) 1 liter/min. (optional)
Interferences (EPA levels)	less than lower detectable limit except for the following NO < 1 ppb, M-Xylene < 1 ppb, H_2O < 3% of reading
Operating temperature	20 - 30°C (may be safely operated over the range of 0 - 45°C)*
Power requirements	90-110 VAC @ 50/60 Hz 105-125 VAC @ 50/60 Hz 210-250 VAC @ 50/60 Hz 100 Watts
Physical dimensions	16.75" (W) X 8.62" (H) X 23" (D)
Weight	44 lbs.
Outputs	selectable voltage 4-20 mA isolated, 4-20 mA non-isolated RS-232/485 Interface

* In non-condensing environments

Any alteration, modification, or republication of this instruction manual or any alteration or modification to the Thermo Environmental Instrument product without the express written consent of Thermo Environmental Instruments Inc. is expressly prohibited, nullifies our warranty obligations, and bars our liability for any damages deriving therefrom.

CHAPTER 2
INSTALLATION

The installation of the Model 43C Trace Level includes lifting the instrument, unpacking the instrument, connecting sample, zero, span, and exhaust lines to the instrument, and attaching the analog outputs to a recording device. The installation should always be followed by calibration of the analyzer as described in Chapter 4, "Calibration."

LIFTING

A procedure appropriate to lifting a heavy object should be used when lifting the analyzer. This procedure consists of bending at the knees while keeping your back straight and upright. The analyzer should be grasped at the bottom, in the front and at the rear of the unit. Do not attempt to lift the analyzer by the cover or other external fittings. While one person may lift the unit, it is desirable to have two persons lifting, one by grasping the bottom in the front and the other by grasping the bottom in the rear.

UNPACKING

The Model 43C Trace Level is shipped complete in one container. If, upon receipt of the analyzer, there is obvious damage to the shipping container, notify the carrier immediately and hold for inspection. The carrier, and not Thermo Environmental Instruments Inc., is responsible for any damage incurred during shipment. Follow the procedure below to unpack and inspect the instrument.

1. Remove the instrument from the shipping container and set on a table or bench that allows easy access to both the front and rear of the instrument.
2. Remove the instrument cover to expose the internal components.
3. Remove any packing material.
4. Check for possible damage during shipment.
5. Check that all connectors and printed circuit boards are firmly attached.
6. Re-install the instrument cover.

SETUP PROCEDURE

1. Connect the sample line to the **SAMPLE** bulkhead on the rear panel of the instrument. Ensure that the sample is not contaminated by dirty, wet, or incompatible materials in the sample line. Use FEP Teflon®, 316 stainless steel, borosilicate glass, or similar tubing with an OD of 1/4" and a minimum ID of 1/8" for all sample lines and components. The length of the tubing should be less than 10 feet.

> **NOTE:** Gas must be delivered to the instrument at atmospheric pressure. It may be necessary to employ an atmospheric bypass plumbing arrangement, as shown in Figure 2-2.

   If the sample contains particulates larger that 5 microns, it should be filtered before introduction into the instrument. A filter (part no. 6655) which does not interact with SO_2 in the sample should be used. If a sample filter is used, all calibrations and span checks must be performed through the filter. The filter element should be replaced regularly to prevent the absorption of SO_2 by trapped material on the filter.
2. Connect the **EXHAUST** bulkhead to a suitable vent. The exhaust line should be 1/4" OD with a minimum ID of 1/8". The length of the exhaust line should be less than 10 feet. Verify that there is no restriction in this line.
3. Connect a suitable recording device to the rear panel terminals. Two 0-10 volt recorder outputs are supplied in the standard instrument. Terminals 1 and 2 are the ground and signal terminals for data output one. Terminals 3 and 4 are the ground and signal terminals for data output two.
4. Plug the instrument into an outlet of the appropriate voltage and frequency.

> **CAUTION:** The Model 43C Trace Level is supplied with a three-wire grounding cord. Under no circumstances should this grounding system be defeated.

To install optional equipment see Chapter 9, “Optional Equipment.”

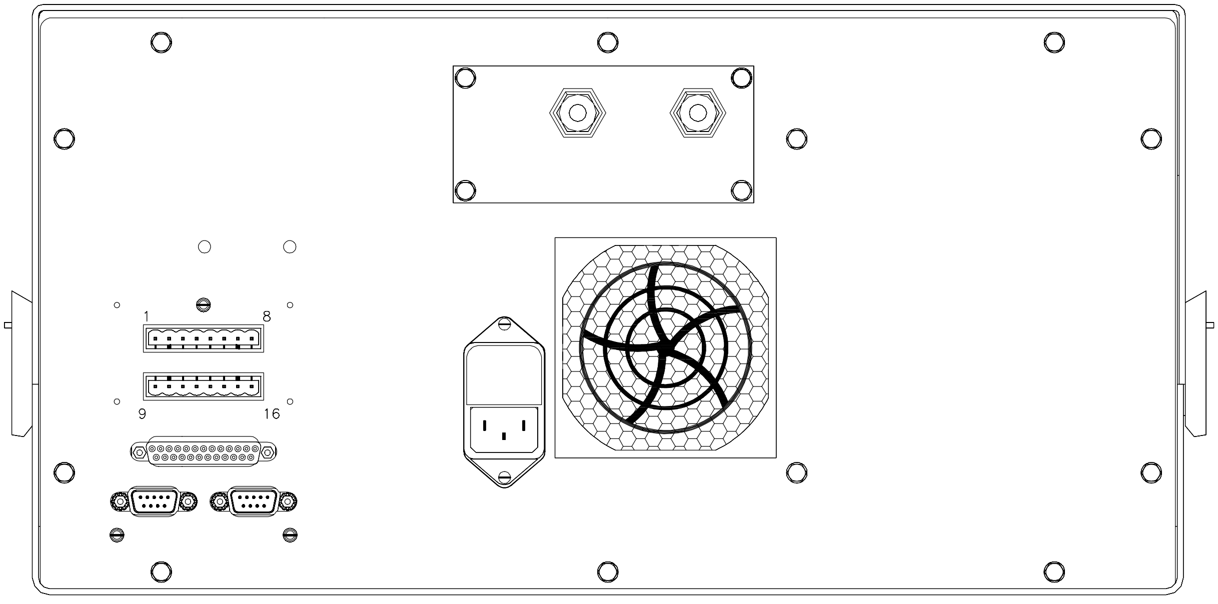


Figure 2-1. Model 43C Trace Level Rear Panel 57P7122R

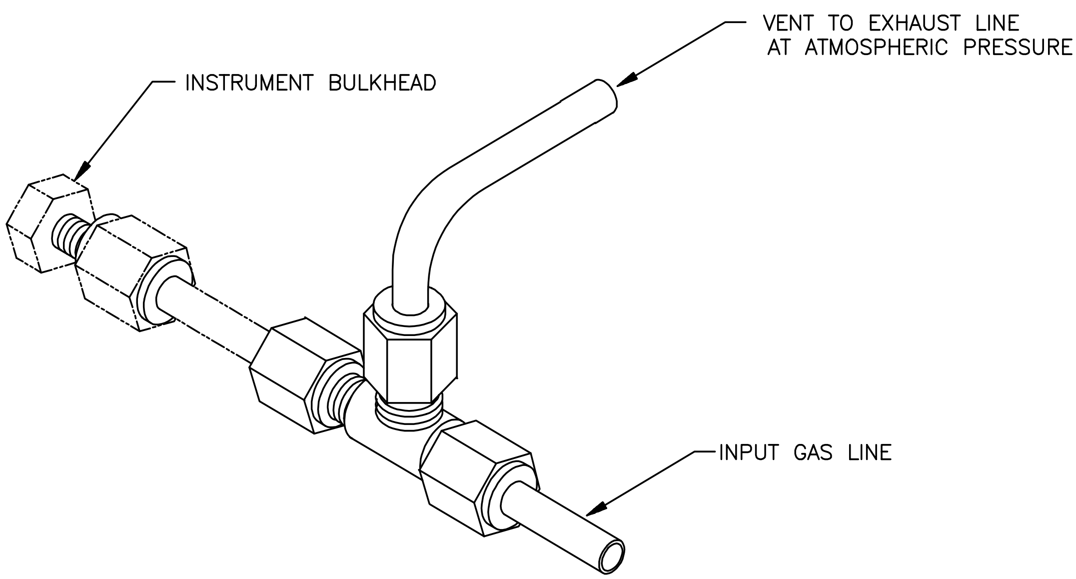


Figure 2-2. Atmospheric Dump Bypass Plumbing 57P7100

Analog Output Cover Installation

The analog output cover must be mounted over the analog outputs to comply with 89/336/EEC Directive. This procedure describes how to install the user-supplied analog output cable in the instrument's analog output cover. The following shielded cables or their equivalent are recommended:

Cable	Gauge	No. of Conductors
Alpha #1741C	20	2
Alpha #1746C	18	2
Alpha #5320/2C*	20	2
Alpha #51 52C*	20	2
Alpha #5162C*	18	2
Alpha #1743C	20	4
Alpha 1747/4C	18	4
Alpha #5320/4C	20	4
Alpha #5154C	20	4
Alpha #5164C	18	4
Belden #8208	18	2

* Maximum shielding. Under harsh environments, maximum shielding may be required.

The following tools are required:

Small screwdriver
Wire stripper
Electrical tape or heat shrink tubing

The user-supplied shielded analog output cable must be properly grounded by coming into full contact with the cable clamp (mounted to the analog output cover). To ensure full contact, the shielding must be exposed and folded back over the cable as shown in Figure 2-3.

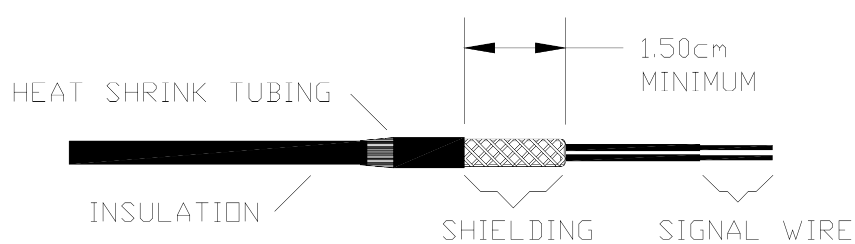


Figure 2-3. Shielded Cable with Shielding Pulled Back

Follow the procedure below to prepare the shielded cable:

1. Remove about 1.8 cm of insulation from the cable.
2. Fold back the shielding.
3. Use electrical tape or shrink tubing to hold the shielding in place. Be sure at least 1.5 cm of shielding is exposed.
4. Strip each signal wire.

Follow the procedure below to connect the shielded cable to the 8-position header:

1. Pass the shielded cable through the cable clamp on the analog output cover, as shown in Figure 2-4.

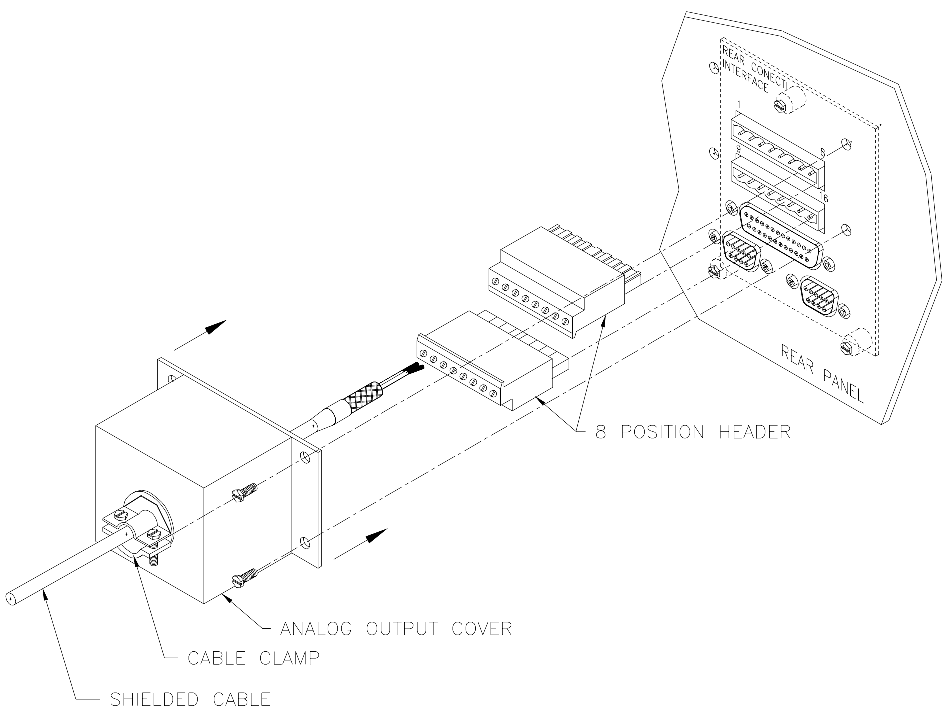


Figure 2-4. Exploded View of Analog Output Cover Installation

2. Insert the bare signal wire into the slot of the header.
3. Tighten down the corresponding set screw.
4. Repeat steps 2 and 3 for each signal wire.
5. Plug the header(s) into the analog output connectors.
6. Install the analog output cover using the four #6 screws with star lockwashers.
7. Position the cable shielding so that it. comes in contact with the cable clamp.
8. Tighten down the cable clamp onto the shielding, as shown in Figure 2-5.

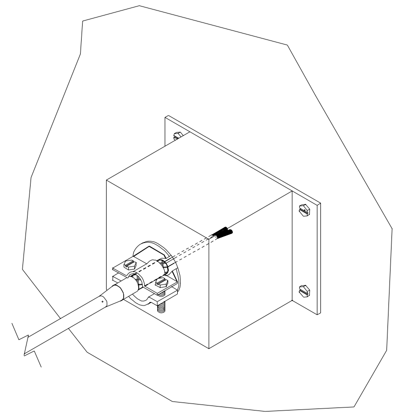


Figure 2-5. Properly Installed Shield Cable

1. Install cable clamp into shield cover and secure. Be sure there is good electrical conductivity between clamp and shield cover.

The following is a parts list of components in the analog output cover assembly:

Part No.	Description	Qty.
7592	Analog output cover	1
11519	8-Position header	2
5889	#6 Star lock washers	4
5820	6-32X3/8” screw	4
14549	Cable clamp	1

STARTUP

1. Turn the power on.
2. Allow 30 minutes for the instrument to stabilize.
3. Set the instrument parameters such as operating ranges and averaging times to the appropriate settings. For more information about instrument parameters, see Chapter 3, “Operation.”
4. Before beginning actual monitoring, perform a multipoint calibration as described in Chapter 4, “Calibration.”

CHAPTER 3
OPERATION

This chapter describes the front panel display, front panel pushbuttons, and menu-driven software.

DISPLAY

The 4 line by 20 character alphanumeric display shows the sample concentrations, instrument parameters, instrument controls, and help messages. Some menus contain more items than can be displayed at one time. For these menus, use the ↑ and ↓ pushbuttons to move the cursor up and down to each choice.

PUSHBUTTONS

Run Pushbutton

The **RUN** pushbutton, shown below, is used to display the Run screen. The Run screen normally displays the SO_2 concentration. In addition, the **RUN** pushbutton is used to switch the optional zero/span and sample solenoid valves. For more information about the optional solenoid valves, see Chapter 9, "Optional Equipment."

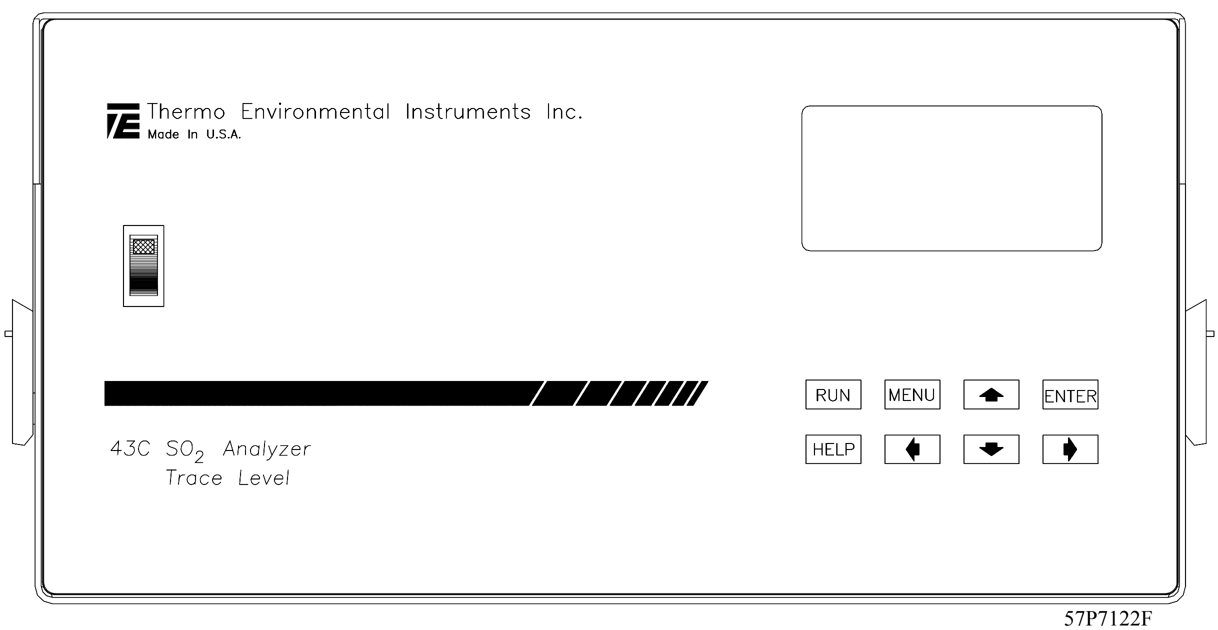


Figure 3-1. Model 43C Trace Level Front Panel

Menu Pushbutton

The **MENU** pushbutton is used to display the Main Menu and to display submenus. When in the Run screen, this pushbutton displays the Main Menu. When in any other screen, a submenu is displayed. For more information about the Main Menu, see "Main Menu" later in this chapter.

Enter Pushbutton

The **ENTER** pushbutton is used to choose a menu item, complete an entry, and toggle on/off functions.

Help Pushbutton

The **HELP** pushbutton is context-sensitive, that is, it provides additional information about the screen that is being displayed. Press the **HELP** pushbutton for a concise explanation about the current screen or menu. Help messages are displayed using lower case letters to easily distinguish them from the operating screens. To exit a help screen, press **MENU** to return to the previous screen or **RUN** to return to the Run screen.

↑ ↓ ← → Pushbuttons

The four arrow pushbuttons (↑, ↓, ←, and →) move the cursor up, down, right, and left.

SOFTWARE OVERVIEW

The Model 43C Trace Level is based on menu-driven software as illustrated by the flowchart in Figure 3-2. The Power-Up and Self-Test screens, shown at the top of the flowchart, are displayed each time the instrument is turned on. These screens are displayed while the instrument is warming up and performing self-checks. After the warm-up period, the Run screen is automatically displayed. The Run screen is the normal operating screen. It is where the SO_2 concentration is displayed. From the Run screen, the Main Menu can be displayed by pressing the **MENU** pushbutton. The Main Menu contains a list of submenus. Each submenu contains related instrument parameters and/or functions. This chapter describes each submenu and screen in detail. Refer to the appropriate sections for more information.

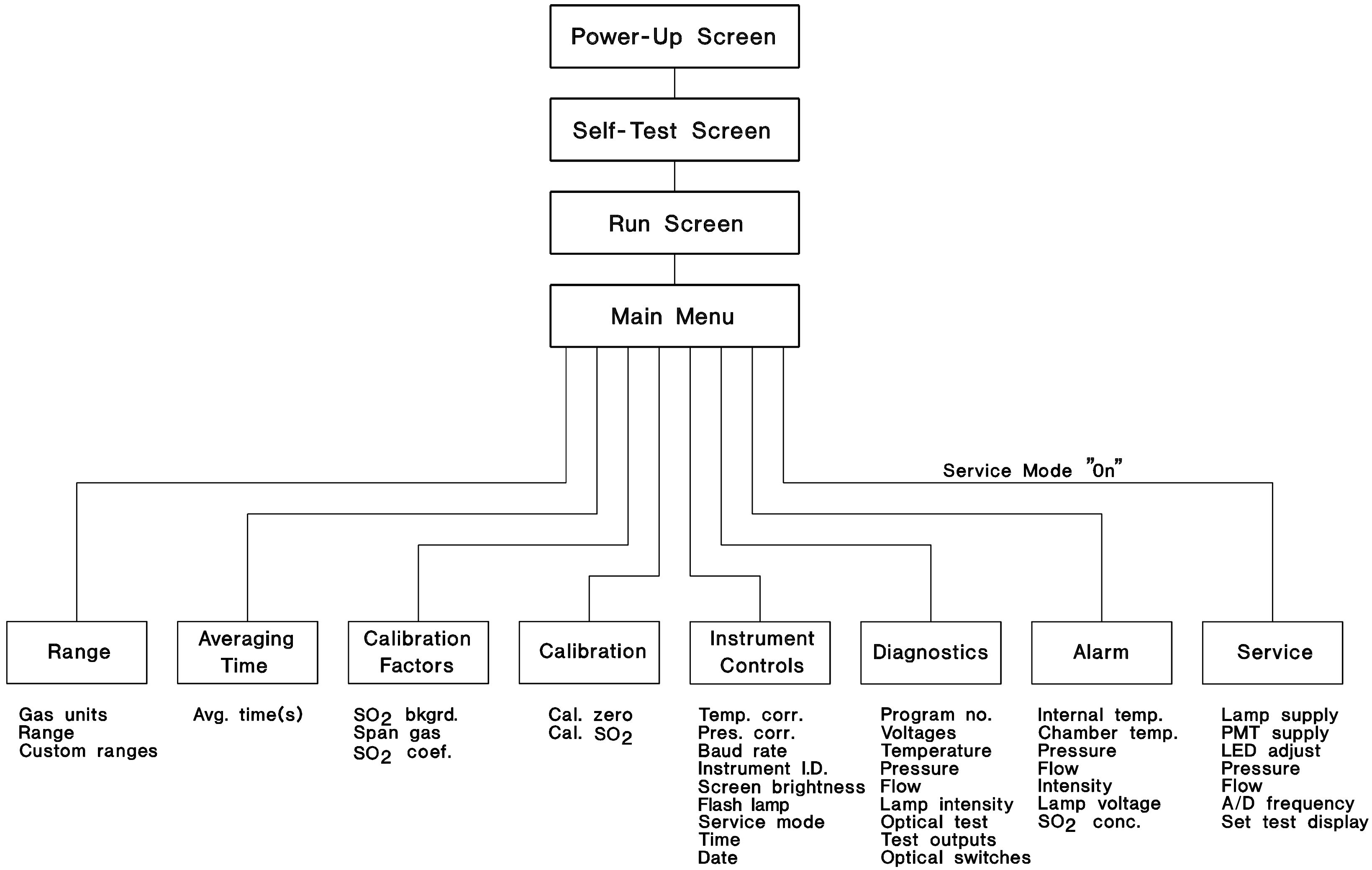


Figure 3-2. Flowchart of Menu-Driven Software

Power-Up Screen

The Power-Up screen, as shown below, is displayed on power up of the Model 43C Trace Level.

```
THERMO ENVIRONMENTAL
    INSTRUMENTS
     MODEL 43C
    TRACE LEVEL
```

Power-Up Screen

Self-Test Screen

The Self-Test Screen, as shown below, is displayed while the internal components are warming up and a diagnostic check is performed.

```
     MODEL 43C
    TRACE LEVEL
     SELF TEST
12/05/94       11:30
```

Self Test Screen

Run Screen

The Run screen, shown below, normally displays the SO_2 concentration and the time. It also displays the status of the remote interface and zero/span and sample solenoid valves. For more information about optional equipment, see Chapter 9, “Optional Equipment.”

```
SO2 PPB          25.5
       10:25   REMOTE
```

Run Screen

Main Menu

The Main Menu contains several submenus as shown below. Instrument parameters and features are divided into these submenus according to their function. Use the ↑ and ↓ pushbuttons to move the cursor to each submenu. When the Main Menu is entered directly from the Run screen, the ← pushbutton may be used to jump to the most recently displayed submenu screen. Use the **ENTER** pushbutton to select a submenu.

```
MAIN MENU:      10:25
>RANGE
 AVERAGING TIME
 CALIBRATION FACTORS

 CALIBRATION
 INSTRUMENT CONTROLS
 DIAGNOSTICS
 ALARM
```

Main Menu

RANGE MENU

The Range menu appears as shown below. In the upper right corner of the display, the word single, dual, or auto is displayed to indicate the active mode. The Range menu in the dual and autorange modes appear the same except for the word dual or auto, displayed in the upper right corner. For more information about the single, dual, or autorange modes, see “Single Range Mode,” “Dual Range Mode,” and “Autorange Mode” below.

To display the Range Menu:

- ▶ From the Main Menu choose Range

To use the Range Menu:

- ▶ Press the ↑ and ↓ pushbuttons to move the cursor to each choice
- ▶ Press **ENTER** to select a choice
- ▶ Press **MENU** to return to the Main Menu
- ▶ Press **RUN** to return to the Run screen

```
RANGE:          SINGLE
>GAS UNITS         PPB
 RANGE              50
 SET CUSTOM RANGES
```

```
RANGE:            DUAL
>GAS UNITS         PPB
HI RANGE           100
LO RANGE            50

 SET CUSTOM RANGES
```

Range Menu in Single and Dual/Autorange Mode

Single Range Mode

In the single range mode, there is one range, one averaging time, and one span coefficient. The two SO_2 analog outputs are arranged on the rear panel terminal strip as shown in Figure 3-3. To use the single range mode, set option switches 4 and 5 off. For more information about setting the internal option switches, see "Internal Option Switches," later in this chapter.

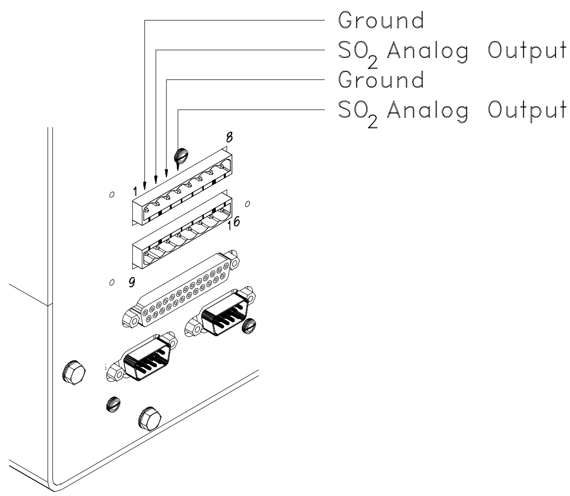


Figure 3-3. Pin-Out of Rear Panel Terminal Strip in Single Range Mode 57P965-2

Dual Range Mode

In the dual range mode, there are two independent SO_2 analog outputs as shown below.

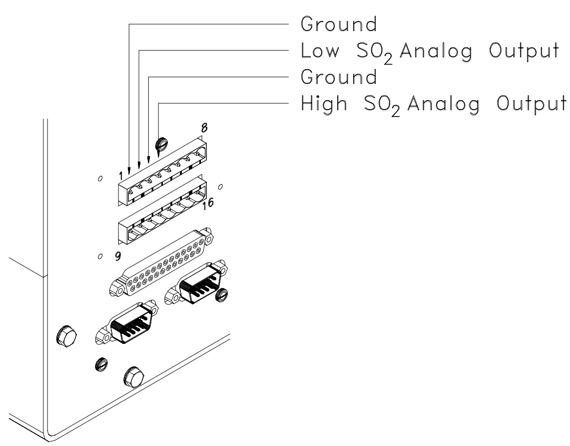


Figure 3-4. Pin-Out of Rear Panel Terminal Strip in Dual Range Mode 57P965-3

There are two ranges, high SO_2 range and low SO_2 range, that correspond to the high SO_2 and low SO_2 analog outputs, respectively. This enables the sample concentration reading to be sent to the analog outputs at two different ranges. For example, the low SO_2 analog output can be set to output concentrations from 0 to 50 ppb and the high SO_2 analog output set to output concentrations from 0 to 100 ppb. The low SO_2 and high SO_2 range can be set to the same range in order to provide two identical outputs.

In addition, each SO_2 analog output has a span coefficient. There are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to one another. For example, the low SO_2 range is set to 0-10 ppb and the high SO_2 range is set to 0-1000 ppb. To use the dual range mode, set option switch 4 on and option switch 5 off. For more information about setting the internal option switches, see "Internal Option Switches," later in this chapter.

Autorange Mode

The autorange mode switches the SO_2 analog output between a high SO_2 range and a low SO_2 range, depending on the concentration level. The high SO_2 range and the low SO_2 range are defined in the Range menu. When concentrations are below the low SO_2 range, the SO_2 analog output uses the low SO_2 range. When concentrations are above the low SO_2 range, the SO_2 analog output uses the high SO_2 range.

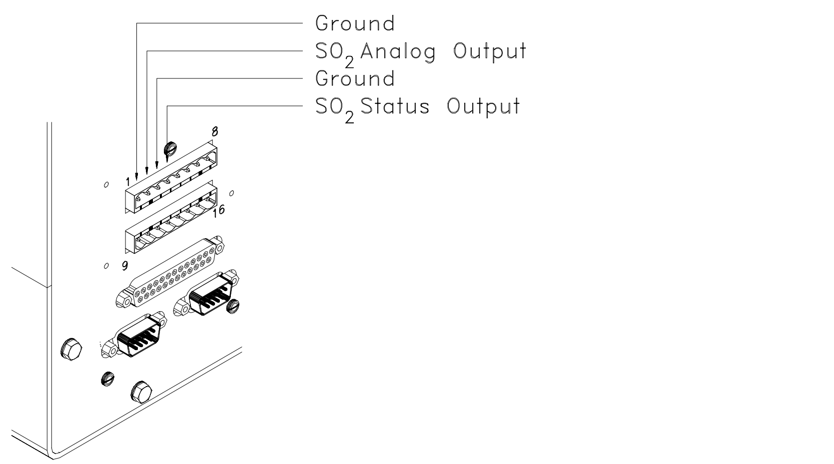


Figure 3-5. Pin-Out of Rear Panel Terminal Strip in Autorange Mode

For example, suppose the low SO_2 range is set to 50 ppb and the high SO_2 range is set to 100 ppb. Sample concentrations below 50 ppb are presented to the SO_2 analog output using the low SO_2 range, as shown below. Sample concentrations above 50 ppb are presented to the SO_2 analog output using the high SO_2 range. The SO_2 status output indicates which range the SO_2 analog output is using. When the low SO_2 range is active, the SO_2 status output is at 0 volts. When the high SO_2 range is active, the SO_2 status output is at 50% of fullscale.

When the high SO_2 range is active, the concentration must drop to 85% of the low SO_2 range for the low SO_2 range to become active.

In addition, there are two span coefficients so that each range can be calibrated separately. This is necessary if the two ranges are not close to each other another. For example, the low SO_2 range is set to 0-10 ppb and the high SO_2 range is set to 0-1000 ppb.

To use the autorange mode, set option switch 4 and 5 on. For more information about setting the internal option switches, see “Internal Option Switches,” later in this chapter.

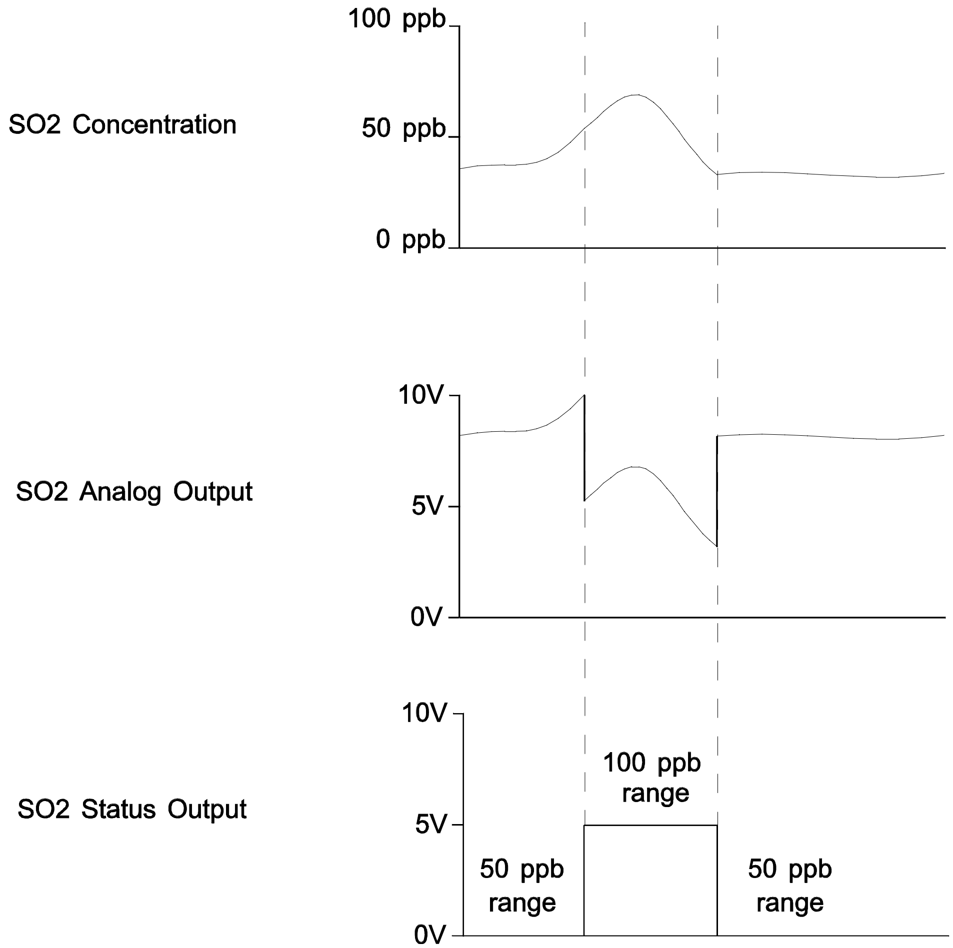


Figure 3-6. Analog Output in Autorange Mode

Gas Units

The Gas Units screen, shown below, defines how the SO_2 concentration reading is expressed. Gas Units of parts per billion (ppb) or micrograms per cubic meter ($\mu g/m^3$) are available. The $\mu g/m^3$ gas concentration modes are calculated using a factory standard pressure of 760 mm Hg and a factory standard temperature of 20°C.

When switching from ppb to $\mu g/m^3$ or vice versa, the SO_2 range and custom ranges are set to default to the highest range in that mode. For example, when switching from $\mu g/m^3$ to ppb, all ranges will be set to 1000 ppb.

The current gas units are shown on the first line of the display. The gas units are selected on the second line of the display.

To display the Gas Units screen:

- ▶ From the Main Menu choose Range
- ▶ From the Range Menu choose Gas Units

To use the Gas Units screen:

- ▶ Use the ↑ and ↓ pushbuttons to select the gas units
- ▶ Press **ENTER** to accept the choice
- ▶ Press **MENU** to return to the Range menu
- ▶ Press **RUN** to return to the Run screen

```
GAS UNITS          PPB
SET TO          UG/M3?
& RANGES TO DEFAULT?
↑↓ SELECT
```

Gas Units Screen

Range

The Range screen defines the concentration range of the analog outputs. For example, a SO_2 range of 0-50 ppb restricts the analog output to concentrations between 0 and 50 ppb.

The second line of the display shows the current SO_2 range. The third line of the display is used to change the range. The range screen is similar for the single, dual, and autorange modes as shown below. For more information about the single, dual, or autorange modes, see “Single Range Mode,” “Dual Range Mode,” and “Autorange Mode” earlier in this chapter.

Table 3-1 lists the available preset ranges.

To display the Range screen:

- ▶ From the Main Menu choose Range
- ▶ From the Range menu choose Range

To use the Range screen:

- ▶ Use the ↑ and ↓ pushbuttons to scroll through the preset ranges
- ▶ Press **ENTER** to accept a range
- ▶ Press **MENU** to return to the Range menu
- ▶ Press **RUN** to return to the Run screen

```
RANGE:
SO2 PPB             50.0
SET TO             100.0?
↑↓ SELECT
```

```
LOW RANGE:
SO2 PPB             50.0
SET TO             100.0?
↑↓ SELECT
```

Range Screens in Single and Dual/Autorange Modes

ppb	$\mu g/m^3$
10	20
20	50
50	100
100	200
200	500
500	1,000
1,000	2,000
C1	C1
C2	C2
C3	C3

Table 3-1. Standard Ranges

C1, C2, and C3 are custom ranges. For more information about custom ranges, see "Custom Ranges Menu" below.

Custom Ranges Menu

The Custom Ranges Menu, shown below, lists three custom ranges: C1, C2, and C3. Custom ranges are user-defined ranges. In the standard range mode, any value between 10 ppb (20 μg/m^3) and 1000 ppb (2000 μg/m^3) can be specified as a range. See "Custom Range Screen" below for more information about defining the custom ranges.

To display the Set Custom Ranges menu:

- ► From the Main Menu choose Range
- ► From the Range menu choose Set Custom Ranges

To use the Set Custom Ranges menu:

- ► Use the ↑ and ↓ pushbutton to move the cursor between each custom range
- ► Press **ENTER** to select the custom range to define
- ► Press **MENU** to return to the Range menu
- ► Press **RUN** to return to the Run screen

```
SET CUSTOM RANGES:
>C1 PPB         55.6
 C2 PPB         75.0
 C3 PPB         85.0
```

Set Custom Ranges Menu

Custom Range Screen. The Custom Range screen, shown below, is used to define the custom range.

The first line of the display shows the current custom range. The second line of the display is used to set the range. To use the custom fullscale range be sure to select either C1, C2, or C3 in the Range screen. See “Range” above for more information.

To display the Custom Range screen:

- ► From the Main Menu choose Range
- ► From the Range menu choose Set Custom Ranges
- ► From the Set Custom Range menu choose C1, C2, or C3

To use the Custom Range screen:

- ► Use the ↑ and ↓ pushbutton to increment and decrement each digit
- ► Use the ← and → pushbutton to move the cursor left and right
- ► Press **ENTER** to accept the custom range
- ► Press **MENU** to return to the Set Custom Ranges menu
- ► Press **RUN** to return to the Run screen

```
C1 PPB      000055.6
SET TO      000055.7?

↑↓ INC/DEC ←→ CURSOR
```

Set Custom Range 1 Screen

AVERAGING TIME

The averaging time defines a time period (1 to 300 seconds) during which SO_2 measurements are taken. The average concentration of the readings are calculated for that time period. The front panel display and analog outputs are updated every 10 seconds for averaging times between 10 and 300 seconds. For averaging times of 1, 2, and 5 seconds, the front panel display and analog outputs are updated every one second. An averaging time of 10 seconds, for example, means that the average concentration of the last 10 seconds will be output at each update. An averaging time of 300 seconds means that the moving average concentration of the last 300 seconds will be output at each update. Therefore, the lower the averaging time the faster the front panel display and analog outputs respond to concentration changes. Longer averaging times are typically used to smooth output data.

The Averaging Time screen for the single range and autorange mode is shown below. In the dual range mode, an Averaging Time menu is displayed before the averaging time screen. This menu is needed because the dual range mode has two Averaging Times (high and low). The Averaging Time screens function the same way in the single, dual and autorange modes. The following averaging times are available: 1, 2, 5, 10, 20, 30, 60, 90, 120, 180, 240, and 300 seconds.

To display the Averaging Time menu/screen:

► From the Main Menu choose Averaging Time

To use the Averaging Time screen:

► Use the ↑ and ↓ pushbuttons to select the averaging time
► Press **ENTER** to accept the averaging time
► Press **MENU** to return to the Main Menu
► Press **RUN** to return to the Run screen

```
AVG TIME      10 SEC
SET TO        10 SEC

↑↓ SELECT
```

Averaging Time Screen

CALIBRATION FACTORS MENU

Calibration factors are determined during automatic and manual calibration and are used to correct the SO_2 concentration readings. The Calibration Factors menu displays the calibration factors as shown below. Normally the instrument is calibrated automatically, that is, using the Calibration menu. However, the instrument can be calibrated manually using this menu. To manually calibrate the instrument, see "SO_2 Background Correction" and "SO_2 Span Coefficient" below for more information.

To display the Calibration Factors menu:

► From the Main Menu choose Calibration Factors:

To use the Calibration Factors menu:

► Use the ↑ and ↓ pushbuttons to move the cursor up and down
► Press **ENTER** to go to the Calibration Factor screen
► Press **MENU** to return to the Main Menu
► Press **RUN** to return to the Run screen

```
CALIBRATION FACTORS:
>SO2 BKG PPB      2.7
 SPAN GAS        70.0
 SO2 COEF       1.000
```

```
CALIBRATION FACTORS:
>SO2 BKG PPB      2.7
 HI SPAN GAS     70.0
 HI SO2 COEF    1.000

 LO SPAN GAS     80.0
 LO SO2 COEF    1.000
```

Calibration Factors Menu in Single and Dual/Autorange Modes

SO_2 Background Correction

The SO_2 background correction is determined during zero calibration. The SO_2 background is the amount of signal read by the analyzer while sampling zero air. The background signal is a combination of electrical noise and scattered light. Before the analyzer sets the SO_2 reading to zero, it stores the value as the SO_2 background correction.

The SO_2 Background screen is used to perform a manual zero calibration of the instrument. As such, the instrument should sample zero air until stable readings are obtained. The first line of the display shows the current SO_2 reading. This reading is the SO_2 background signal. The second line of the display shows the SO_2 background correction that is stored in memory and is being used to correct the SO_2 reading. That is, the SO_2 background correction is subtracted from the SO_2 reading.

In the example below, the analyzer is reading 2.7 ppb of SO_2 while sampling zero air. The SO_2 background correction is 0.0 ppb. That is, the analyzer is not applying a zero background correction. The question mark is used as a prompt to change the background correction. In this case the background correction must be increased to 2.7 ppb in order for the SO_2 reading to be at 0 ppb.

To set the SO_2 reading in the example below to zero, use the ↑ pushbutton to increment the SO_2 background correction to 2.7 ppb. As the SO_2 background correction reading is increased, the SO_2 reading is decreased. At this point however, no real changes have been made. To escape without making any changes, press the **MENU** pushbutton to return to the Calibration Factors menu or the **RUN** pushbutton to return to the Run screen. Press the **ENTER** pushbutton to set the SO_2 reading to 0.0 ppb and store the background correction of 2.7 ppb.

To display the SO_2 Background screen:

- ► From the Main Menu choose Calibration Factors
- ► From the Calibration Factors menu choose SO_2 Background

To use the SO_2 Background screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the SO_2 background
- ► Press **ENTER** to accept a change in the background
- ► Press **MENU** to return to the Calibration Factors menu
- ► Press **RUN** to return to the Run screen

```
SO2 PPB            2.7
BACKGROUND         0.0?

↑↓ INC/DEC
```

SO_2 Background Screen

Span Gas

The Span Gas screen represents the last stored span setting.

To display the Span Gas screen:

- ► From the Main Menu choose Calibration Factors
- ► From the Calibration Factors menu choose Span Gas

To use the Span Gas screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the Span Gas
- ► Press **ENTER** to accept a change in the Span Gas
- ► Press **MENU** to return to the Calibration Factors menu
- ► Press **RUN** to return to the Run screen

```
SPAN GAS:
PPM          00070.00
SET TO       00080.00 ?
↑↓ INC/DEC
```

Span Gas Screen

SO_2 Span Coefficient

The SO_2 span coefficient is calculated during calibration. The span coefficient is used to correct the SO_2 readings and normally has a value near 1.000.

The SO_2 Span Coefficient screen enables the SO_2 span coefficient to be manually changed while sampling span gas of known concentration. The first line of the display shows the current SO_2 concentration reading. The second line of the display shows the SO_2 span coefficient that is stored in memory and is being used to correct the SO_2 concentration. Notice that as the span coefficient value is changed using the ↑ and ↓ pushbuttons, that the current SO_2 concentration reading on the first line also changes.

To display the SO_2 Span Coefficient screen:

- ► From the Main Menu choose Calibration Factors
- ► From the Calibration Factors menu choose SO_2 Coef

To use the SO_2 Span Coefficient screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the span coefficient
- ► Press **ENTER** to accept a change
- ► Press **MENU** to return to the Calibration Factors menu
- ► Press **RUN** to return to the Run screen

```
SO2 PPB          51.4
SO2 COEF        1.000?

↑↓ INC/DEC
```

SO_2 Span Coefficient Screen

CALIBRATION MENU

The Calibration menu is used to calibrate zero and span. The calibration menu is similar for the single, dual, and autorange mode as shown below. The dual and autorange modes have two SO_2 span factors ("Hi" and "Lo"). This allows each range to be calibrated separately. This is necessary if the two ranges used are not close to one another. For example a low SO_2 range of 10 ppb and a high SO_2 range of 1000 ppb. For more information about calibration, see Chapter 4, “Calibration.”

To display the Calibration menu:

► From the Main Menu choose Calibration

To use the Calibration menu:

► Use the ↑ and ↓ pushbuttons to move the cursor up and down
► Press **ENTER** to accept the choice
► Press **MENU** to return to the Main Menu
► Press the **RUN** to return to the Run screen

```
CALIBRATION:
>CALIBRATE ZERO
 CALIBRATE SO2
```

```
CALIBRATION:
>CALIBRATE ZERO
 CALIBRATE HI SO2
 CALIBRATE LO SO2
```

Calibration Menu in Single and Dual/Autorange Modes

Calibrate Zero

The Calibrate Zero screen, shown below, is used to perform a zero calibration. The second line of the display shows the current SO_2 reading. Before performing a zero calibration, ensure that the analyzer samples zero air for at least 5 minutes. For more information about the SO_2 background, see “SO_2 Background Correction,” earlier in this chapter.

To display the Calibrate Zero screen:

- ► From the Main Menu choose Calibration
- ► From the Calibration menu choose Calibrate Zero

To use the Calibrate Zero screen:

- ► Press **ENTER** to set the SO_2 reading to zero
- ► Press **MENU** to return to the Calibration menu
- ► Press **RUN** to return to the Run screen

```
SO2 PPB          2.7
SET TO         ZERO?
```

Zero Calibration Screen

Calibrate SO_2

The Calibrate Span screen is used to adjust the SO_2 span concentration while sampling span gas of known concentration. The first line of the display shows the current SO_2 concentration reading. The second line of the display shows the current SO_2 range. The third line of the display is where the SO_2 calibration gas concentration is entered.
The SO_2 span coefficient is calculated, stored, and used to correct the current SO_2 reading. For more information about calibration, see Chapter 4, "Calibration."

To display the Calibrate SO_2 screen:

- ► From the Main Menu choose Calibration
- ► From the Calibration menu choose Calibrate SO_2

To use the Calibrate SO_2 screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement each digit
- ► Use the ← and → pushbuttons to move the cursor left and right
- ► Press **ENTER** to calibrate the SO_2 reading to the SO_2 calibration gas
- ► Press **MENU** to return to the Calibration menu
- ► Press **RUN** to return to the Run screen

```
SO2 PPB          79.1
RANGE           100.0
SET TO       000080.0
↑↓ INC/DEC
```

SO_2 Calibration Screen

INSTRUMENT CONTROLS MENU

The Instrument Controls menu is shown below. The software controls in this menu control instrument functions.

To display the Instrument Controls Menu:

► From the Main Menu choose Instrument Controls

To use the Instrument Controls Menu:

► Use the ↑ and ↓ pushbuttons to scroll through the choices
► Press **ENTER** to select a choice

```
INSTRUMENT CONTROLS:
>TEMP CORRECTION
 PRESSURE CORRECTION
 FLASH LAMP

 BAUD RATE
 INSTRUMENT ID
 SCREEN BRIGHTNESS
 SERVICE MODE
 TIME
 DATE
```

Instrument Controls Menu

Temperature Correction

Temperature correction provides compensation for any changes to the instrument's output signal due to variations in internal instrument temperature. The effects of internal instrument temperature changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate for any changes in temperature.

The temperature correction screen is shown below. When temperature correction is on, the first line of the display shows the current internal instrument temperature (measured by a thermistor on the Motherboard). When temperature correction is off, the first line of the display shows the factory standard temperature of 30^{o}C.

To display the Temperature Correction screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Temperature Correction

To use the Temperature Correction screen:

- ► Press **ENTER** to toggle temperature correction on and off
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
TEMPERATURE   30.0°C
CORRECTION      OFF

TURN            ON?
```

Temperature Correction Screen

Pressure Correction

Pressure correction provides compensation for any changes to the instrument's output signal due to variations of fluorescence chamber pressure. The effects of fluorescence chamber pressure changes on the analyzer's subsystems and output have been empirically determined. This empirical data is used to compensate for any change in fluorescence chamber pressure.

The pressure correction screen is shown below. When pressure correction is on, the first line of the display represents the current pressure in the fluorescence chamber. When pressure correction is off, the first line of the display shows the factory standard pressure of 760 mm Hg.

To display the Pressure Correction screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Pressure Correction

To use the Pressure Correction screen:

- ► Press **ENTER** to toggle pressure correction on and off
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
PRESSURE 760.0 mm Hg
CORRECTION      OFF

TURN            ON?
```

Pressure Correction Screen

Flash Lamp

The Flash Lamp screen, shown below, turns the flash lamp on and off. The flash lamp must be off when using the optical test LED. For more information about the optical test LED, see “Optical Test LED,” later in this chapter.

To display the Flash Lamp screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Flash Lamp

To use the Flash Lamp screen:

- ► Use the **ENTER** pushbutton to toggle the flash lamp on and off
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
FLASH LAMP        ON
TURN            OFF?
```

Flash Lamp Screen

Baud Rate

The Baud Rate screen, shown below, is used to set the RS-232 interface baud rate. Baud rates of 1200, 2400, 4800, and 9600 are available.

To display the Baud Rate screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Baud Rate

To use the Baud Rate screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the baud rate
- ► Press **ENTER** to accept a change
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
BAUD RATE       4800
                9600?

↑↓ INC/DEC
```

Baud Rate Screen

Instrument ID

The Instrument ID screen, shown below, enables the Instrument ID to be user-defined. This is useful if two or more of the same instrument are connected to one computer. Valid Instrument ID numbers are from 0 to 99. The Model 43C Trace Level has a default Instrument ID of 33. For more information about the Instrument ID, see Appendix B, "RS-232/485 Commands."

To display the Instrument ID screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Instrument ID

To use the Instrument ID screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the ID number
- ► Press **ENTER** to accept a change
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
INSTRUMENT ID     33
SET TO            43?

↑↓ INC/DEC
```

Instrument ID Screen

Screen Brightness

The Screen Brightness screen, shown below, is used to change the screen brightness. Intensities of 25%, 50%, 75%, and 100% are available. Changing the screen brightness to a lower intensity will extend the life of the display.

To display the Screen Brightness screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Screen Brightness

To use the Screen Brightness screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the screen brightness
- ► Press **ENTER** to accept a change
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
BRIGHTNESS      100 %
SET TO           25 %?

↑↓ INC/DEC
```

Screen Brightness Screen

Service Mode

The Service Mode screen, shown below, is used to turn the service mode on and off. The service mode includes parameters and functions that are useful when making adjustments or diagnosing the Model 43C Trace Level. Meaningful data should not be collected when the instrument is in the service mode. For more information about the service mode, see “Service Mode Menu,” later in this chapter.

To display the Service Mode screen:

► From the Main Menu choose Instrument Controls
► From the Instrument Controls menu choose Service Mode

To use the Service Mode screen:

► Press **ENTER** to toggle service mode on and off
► Press **MENU** to return to the Instrument Controls menu
► Press **RUN** to return to the Run screen

```
SERVICE MODE     OFF
TURN              ON?
```

Service Mode Screen

Time

The internal clock is set by the Time screen as shown below. The first line of the display shows the current time (military). The second line of the display is used to change the time. The internal clock is powered by its own battery when instrument power is off.

To display the Time screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Time

To use the Time screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the hours and minutes
- ► Use the ← and → pushbuttons to move the cursor left and right
- ► Press **ENTER** to accept a change
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
TIME              12:00
SET TO            13:00?

↑↓ INC/DEC ←→ CURSOR
```

Time Screen

Date

The date is set by the Date screen as shown below. The first line of the display shows the current date. The second line of the display is used to change the date. The date is updated by the internal clock.

To display the Date screen:

- ► From the Main Menu choose Instrument Controls
- ► From the Instrument Controls menu choose Date

To use the Date screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the month, day, and year
- ► Use the ← and → pushbutton to move the cursor left and right
- ► Press **ENTER** to accept a change
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
DATE           01/01/96
SET TO         01/02/96?

↑↓ INC/DEC ←→ CURSOR
```

Date Screen

DIAGNOSTICS MENU

The Diagnostics menu, shown below, provides access to diagnostic information and functions. This menu is useful when troubleshooting the instrument.

To display the Diagnostics menu:

- ► From the Main Menu choose Diagnostics

To use the Diagnostics menu:

- ► Use the ↑ and ↓ pushbuttons to move the cursor up and down
- ► Press **MENU** to return to the Main Menu
- ► Press **RUN** to return to the Run screen

```
DIAGNOSTICS:
>PROGRAM NUMBERS
 VOLTAGES
 TEMPERATURES

 PRESSURE
 FLOW
 LAMP INTENSITY
 OPTICAL SPAN TEST
 TEST ANALOG OUTPUTS
 OPTION SWITCHES
```

Diagnostics Menu

Program Number

The Program Number screen, shown below, shows the version numbers of the programs installed. Prior to contacting the factory with any questions regarding the instrument, please note the program numbers.

To display the Program Number screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Program Number

To use the Program Number screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen

```
INSTRUMENT PROGRAM:
 43 TR0003 00
COMMUNICATIONS:
 43LTR0003 00
```

Program Number Screen

Voltages

The Voltages screen as shown below, displays the current dc power supply and PMT power supply voltages. This allows the power supplies to be quickly tested for low or fluctuating voltages without having to use a voltage meter.

To display the Voltages screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Voltages

To use the Voltages screen:

- ► This is a view only screen
- ► Use the ↑ and ↓ pushbuttons to move the cursor up and down
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen

```
VOLTAGES:
>PMT          -576.  V
 LAMP         1004.  V
  +5 SUPPLY     4.9 V

 +15 SUPPLY    15.0 V
 -15 SUPPLY   -14.9 V
 BATTERY        3.2 V
```

Voltages Screen

Temperatures

The Temperatures screen, as shown below, displays the current internal instrument temperature and chamber temperature.

To display the Temperatures screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Temperatures

To use the Temperatures screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen

```
TEMPERATURES:
 INTERNAL     30.0 °C
 CHAMBER      45.2 °C
```

Temperatures Screen

Pressure

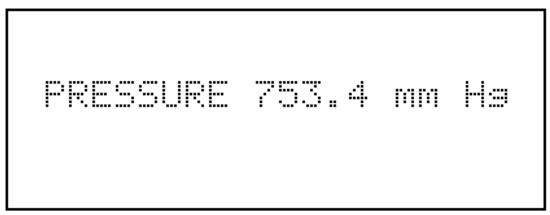
The Pressure screen, shown below, displays the current chamber pressure. The pressure is measured by a pressure transducer in-line with the fluorescence chamber (see Figure 1-1).

To display the Pressure screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Pressure

To use the Pressure screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen



Pressure Screen

Flow

The Flow screen, shown below, displays the current sample flow rate. The flow is measured by an internal flow sensor (see Figure 1-1).

To display the Flow screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Flow

To use the Flow screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen

```
FLOW          0.531 LPM
```

Flow Screen

Lamp Intensity

The Lamp Intensity screen, shown below, displays the current lamp intensity in Hertz.

To display the Lamp Intensity screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu Lamp Intensity

To use the Lamp Intensity screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen

```
INTENSITY   35867.HZ
```

Lamp Intensity Screen

Optical Span Test

The Optical Span Test screen, shown below, turns the optical test LED on and off. Within the fluorescence chamber is a light emitting diode (LED) which may be used to simulate a particular concentration of SO_2. It is designed to provide a quick and easy way of checking the optics and electronics for span drift or other problems.

Potentiometer R7 (LED ADJ) on the Motherboard, adjusts the intensity of the LED. The flash lamp should be turned off when using this feature. See "Flash Lamp" earlier in this chapter for more information.

To display the Optical Span Test screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Optical Span Test

To use the Optical Span Test screen:

- ► Press **ENTER** to toggle the test on and off
- ► Press **MENU** to return to the Diagnostics menu
- ► Press **RUN** to return to the Run screen

```
SO2 PPB          100.3
OPTICAL TEST        ON

TURN              OFF?
```

Optical Test LED Screen

Test Analog Outputs

The Test Analog Outputs menu contains three choices as shown below. These functions enable the analog outputs to be set to zero and fullscale in order to adjust the analog outputs to agree with the front panel display. In addition, a digital to analog (DAC) ramp can be generated to fully test the analog outputs.

To display the Test Analog Outputs menu:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Test Analog Outputs

To use the Test Analog Outputs menu:

- ► Use the ↑ and ↓ pushbuttons to move the cursor up and down
- ► Press **ENTER** to select a choice
- ► Press **MENU** to return to the Instrument Controls menu
- ► Press **RUN** to return to the Run screen

```
SET OUTPUTS TO:
>ZERO
 FULL SCALE
 RAMP
```

Test Analog Outputs Menu

Zero. The Zero screen, as shown below, sets the analog outputs to zero volts. Use the ↑ and ↓ pushbuttons to increment/decrement the output level. For example, to set the analog outputs to 5% of fullscale, use the ↑ pushbutton to increment the 0.0 to 5.0%.

To display the Zero screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Test Analog Outputs
- ► From the Test Analog Outputs menu choose Zero

To use the Zero screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the output level
- ► Press **MENU** to return to the Diagnostics menu and cancel the zero output
- ► Press **RUN** to return to the Run screen and cancel the zero output

```
OUTPUTS          0.0 %
↑↓ INC/DEC
```

Zero Analog Outputs Screen

Fullscale. The Fullscale screen, as shown below, sets the analog outputs to fullscale. Use the ↑ and ↓ pushbuttons to increment/decrement the output level. For example, to set the analog outputs to 95% of fullscale, use the ↓ pushbutton to decrement the 100.0 to 95.0%.

To display the Fullscale screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Test Analog Outputs
- ► From the Test Analog Outputs menu choose Fullscale

To use the Fullscale screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the output level
- ► Press **MENU** to return to the Diagnostics menu and cancel the fullscale output
- ► Press **RUN** to return to the Run screen and cancel the fullscale output

```
OUTPUTS       100.0 %
↑↓ INC/DEC
```

Fullscale Analog Outputs Screen

Ramp. The digital to analog (DAC) ramp is used to fully test the analog outputs. The analog outputs start at -2.3% and then increments by 0.1% every second until it reaches 100.0% (1000). A linear output indicates a that the analog outputs are operating correctly.

To display the Ramp screen:

- ► From the Main Menu choose Diagnostics
- ► From the Diagnostics menu choose Test Analog Outputs
- ► From the Test Analog Outputs menu choose Ramp

To use the Ramp screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Diagnostics menu and cancel the ramp output
- ► Press **RUN** to return to the Run screen and cancel the ramp output

```
OUTPUTS         -2.3 %
```

Ramp Analog Outputs Screen

Option Switches

The Option Switches screen, shown below, enables the settings of the internal option switches to be viewed. Option switch settings cannot be changed through the software. For more information about the internal option switches, see “Internal Option Switches” later in this chapter.

To display the Option Switches screen:

► From the Main Menu choose Diagnostics
► From the Diagnostics menu choose Option Switches

To use the Option Switches screen:

► This is a view only screen
► Use the ↑ and ↓ pushbuttons to move up and down
► Press **MENU** to return to the Diagnostics menu
► Press **RUN** to return to the Run screen

```
OPTION SWITCHES:
>#1 REMOTE            ON
 #2 RS-232            ON
 #3 Z/SPAN VALVE     OFF

 #4 DOUBLE RANGE     OFF
 #5 AUTORANGE        OFF
 #6 LOCK             OFF
 #7 PERM OVEN        OFF
 #8 SPARE            OFF
```

Option Switch Status Screen

ALARMS

The Alarms menu, shown below, displays a list of items that are monitored by the analyzer. If the item being monitored goes outside the lower or upper limit, the status of that item will go from OK to either LOW or HIGH, respectively. The number in the upper right corner of the display indicates how many alarms have occurred. If no alarms are detected, the number zero is displayed.

To see the actual reading of an item and its minimum and maximum limits, move the cursor to the item and press **ENTER**.

To display the Alarms menu:

► From the Main Menu choose Alarm

To use the Alarms menu:

► Use the ↑ and ↓ pushbuttons to move up and down
► Press **ENTER** to see the actual reading and the min and max limits
► Press **MENU** to return to the Main Menu
► Press **RUN** to return to the Run screen

```
ALARMS DETECTED:    0
>INTERNAL TEMP     OK
 CHAMBER TEMP      OK
 PRESSURE          OK

 FLOW              OK
 INTENSITY         OK
 LAMP VOLTAGE      OK
 SO2 CONC          OK
```

Alarm Menu

Internal Temperature

The Internal Temperature screen, shown below, displays the current internal temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 8 to 47°C. If the internal temperature reading goes beyond either the min or max alarm limit, an alarm is activated. The word "Alarm" appears in the Run screen and in the Main Menu.

To display the Internal Temperature screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Internal Temperature

To use the Internal Temperature screen:

- ► Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- ► Press **ENTER** to select a choice (service mode on)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
INTERNAL TEMP:
ACTUAL         28.6°C
>MIN           15.0°C
 MAX           45.0°C
```

Internal Temperature Screen

Min and Max Internal Temperature Limits. The Min Internal Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min internal temperature alarm limit. The Min and Max Internal Temperature screens function the same way.

To display the Min or Max Internal Temperature limit screens (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Internal Temperature
- ► From the Internal Temperature menu choose Min or Max

To use the Min or Max Internal Temperature limit screens (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the Internal Temperature menu
- ► Press **RUN** to return to the Run screen

```
MIN INT.TEMP 15.0°C
SET TO       16.0°C?

↑↓ INC/DEC
```

Set Min Internal Temperature Screen

Chamber Temperature

The Chamber Temperature screen, shown below, displays the current chamber temperature and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 43 to 47°C. If the chamber reading goes beyond either the min or max limit, an alarm is activated. The word "Alarm" appears in the Run screen and in the Main Menu.

To display the Chamber Temperature screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Chamber Temperature

To use the Chamber Temperature screen:

- ► Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- ► Press **ENTER** to select a choice (service mode on)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
CHAMBER TEMP:
ACTUAL          45.4°C
>MIN            43.0°C
 MAX            47.0°C
```

Chamber Temperature Screen

Min and Max Chamber Temperature Limits. The Min Chamber Temperature alarm limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min chamber temperature alarm limit. The Min and Max Chamber Temperature screens function the same way.

To display the Min or Max Chamber Temperature limit screens (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Chamber Temperature
- ► From the Chamber Temperature menu choose Min or Max

To use the Min or Max Chamber Temperature limit screens (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the Chamber Temperature menu
- ► Press **RUN** to return to the Run screen

```
MIN CH.TEMP  43.0°C
SET TO       44.0°C?

↑↓ INC/DEC
```

Set Min Chamber Temperature Screen

Pressure

The Pressure screen, shown below, displays the current fluorescence chamber pressure reading and the factory-set min max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 400 to 1000 mm Hg. If the pressure reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the Pressure screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Pressure

To use the Pressure screen:

- ► Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- ► Press **ENTER** to select a choice (service mode on)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
PRESSURE:
ACTUAL    732.8  mm Hg
>MIN      400.0  mm Hg
 MAX     1000.0  mm Hg
```

Pressure Screen

Min and Max Pressure Limits. The Min Pressure limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min pressure alarm limit. The Min and Max Pressure screens function the same way.

To display the Min or Max Pressure limit screens (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Pressure
- ► From the Pressure menu choose Min or Max

To use the Min or Max Pressure limit screens (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the Pressure menu
- ► Press **RUN** to return to the Run screen

```
MIN PRES  400 mm Hg
SET TO    460 mm Hg?

↑↓ INC/DEC
```

Set Min Pressure Screen

Flow

The Flow screen, shown below, displays the current sample flow reading and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 0 to 1.5 LPM. If the sample flow reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the Sample Flow screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Sample Flow

To use the Sample Flow screen:

- ► Use the ↑ and ↓ pushbuttons to move the cursor up and down (service mode)
- ► Press **ENTER** to select a choice (service mode)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
FLOW:
ACTUAL      0.531 LPM
>MIN        0.350 LPM
 MAX        0.650 LPM
```

Sample Flow Screen

Min and Max Flow Limits. The Min Flow limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min sample flow alarm limit. The Min and Max Sample Flow screens function the same way.

To display the Min or Max Flow limit screen (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Flow
- ► From the Flow menu choose Min or Max

To use the Min or Max Flow limit screen (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the Flow menu
- ► Press **RUN** to return to the Run screen

```
MIN FLOW  0.350 LPM
SET TO    0.360 LPM?

↑↓ INC/DEC
```

Set Min Sample Flow Screen

Intensity

The Intensity screen, shown below, displays the current lamp intensity reading and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 10,000 to 50,000 Hz. If the lamp intensity reading goes beyond either the min or max alarm limit, an alarm is activated. The word "Alarm" appears in the Run screen and in the Main Menu.

To display the Intensity screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Intensity

To use the Intensity screen:

- ► Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- ► Press the **ENTER** pushbutton to select a choice (service mode on)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
LAMP INTENSITY:
ACTUAL       25523 Hz
>MIN         20000 Hz
 MAX         50000 Hz
```

Lamp Intensity Screen

Min and Max Lamp Intensity Limits. The Min Intensity limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min intensity alarm limit. The Min and Max Intensity screens function the same way.

To display the Min or Max Lamp Intensity limit screens (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Intensity
- ► From the Intensity menu choose Min or Max

To use the Min or Max Lamp Intensity limit screens (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the Lamp Intensity menu
- ► Press **RUN** to return to the Run screen

```
MIN INT    20000 Hz
SET TO     25000 Hz?

↑↓ INC/DEC
```

Set Min Lamp Intensity Screen

Lamp Voltage

The Lamp Voltage screen, shown below, displays the current lamp voltage and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. Acceptable alarm limits range from 500 to 1200 volts. If the lamp voltage goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the Lamp Voltage screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Lamp Voltage

To use the Lamp Voltage screen:

- ► Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- ► Press the **ENTER** pushbutton to select a choice (service mode on)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
LAMP VOLTAGE:
ACTUAL          1004 V
>MIN             950 V
 MAX            1200 V
```

Lamp Voltage Screen

Min and Max lamp Voltage Limits. The Min Lamp Voltage limit screen, shown below, is accessible only when the instrument is in the service mode. It is used to change the min lamp voltage alarm limit. The Min and Max Lamp Voltage screens function the same way.

To display the Min or Max Voltage limit screens (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose Lamp Voltage
- ► From the Lamp Voltage menu choose Min or Max

To use the Min or Max Lamp Voltage screens (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the Lamp Voltage menu
- ► Press **RUN** to return to the Run screen

```
MIN LAMP         950 V
SET TO           970 V?

↑↓ INC/DEC
```

Set Min Lamp Voltage Screen

SO_2 Concentration

The SO_2 Concentration screen, shown below, displays the current SO_2 concentration and the factory-set min and max alarm limits. The min and max alarm limits can be changed when the instrument is in the service mode. When using standard ranges, the acceptable alarm limits range from 0 to 1000 ppb. If the SO_2 concentration reading goes beyond either the min or max alarm limit, an alarm is activated. The word “Alarm” appears in the Run screen and in the Main Menu.

To display the SO_2 Concentration screen:

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose SO_2 Concentration

To use the SO_2 Concentration screen:

- ► Use the ↑ and ↓ pushbuttons to move up and down (service mode on)
- ► Press the **ENTER** pushbutton to select a choice (service mode on)
- ► Press **MENU** to return to the Alarm menu
- ► Press **RUN** to return to the Run screen

```
SO2 PPB:
ACTUAL PPB       5.5
>MIN             0.0
 MAX              10
```

SO_2 Concentration Screen

Min and Max SO_2 Concentration Limits. The SO_2 min and max concentration limit screens are accessible only when the instrument is in the service mode. They are used to change the min and max concentration alarm limits. The Min SO_2 concentration screen is shown below.

To display the Min or Max SO_2 Concentration limit screens (service mode on):

- ► From the Main Menu choose Alarm
- ► From the Alarm menu choose SO_2 Concentration
- ► From the SO_2 Concentration menu choose Min or Max

To use the Min or Max SO_2 Concentration limit screens (service mode on):

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the value
- ► Press **ENTER** to accept the change
- ► Press **MENU** to return to the SO_2 Concentration menu
- ► Press **RUN** to return to the Run screen

```
MIN PPB      000000.0
SET TO       000020.0

↑↓ INC/DEC
```

Set Min SO_2 Concentration Screen

SERVICE MODE MENU

The Service Mode menu, shown below, appears only when the instrument is in the service mode. To put the instrument into the service mode, select Instrument Controls from the Main Menu, then from the Instrument Controls menu select Service Mode. When the instrument is in the service mode, the Main Menu extends to include the Service Mode menu. The service mode includes some of the same information found in the Diagnostic menu. However, items such as PMT supply, optical test LED adjust, pressure, and flow readings are updated every 10 seconds in the Diagnostic menu, where in the service mode these readings are updated every second. The rapid update time enables the readings on the display to respond faster to adjustment. In addition, advanced diagnostic functions are included in the service mode. Meaningful data should not be collected when the instrument is in the service mode.

To display the Service Mode menu:

► From the Main Menu choose Service Mode

To use the Service Mode menu:

► Use the ↑ and ↓ pushbuttons to move the cursor up and down
► Press **ENTER** to select a choice
► Press **MENU** to return to the Main Menu
► Press **RUN** to return to the Run screen

```
SERVICE MODE:
>LAMP SUPPLY
 PMT SUPPLY
 ADJUST LED

 PRESSURE
 FLOW
 A/D FREQUENCY
 SET TEST DISPLAY
```

Service Mode Menu

Lamp Supply

The Lamp Supply screen, shown below, shows the lamp intensity and voltage. Both readings are updated every second.

To display the Lamp Supply screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose Lamp Supply

To use the Lamp Supply screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
INTENSITY   46867.HZ
LAMP SUPPLY   554. V
```

Lamp Supply Screen

PMT Supply

The PMT Supply screen, shown below, shows the PMT supply voltage. The PMT supply voltage reading is updated every second. This screen is used while adjusting the PMT voltage.

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the PMT Supply screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose PMT Supply

To use the PMT Supply screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
PMT SUPPLY   - 701 V
```

PMT Supply Screen

Adjust LED

The Adjust LED screen, shown below, shows the LED simulated SO_2 concentration. The LED adjust reading is updated every second. This screen is used while adjusting potentiometer R7 (LED ADJ) on the Motherboard.

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Adjust LED screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose Adjust LED

To use the Adjust LED screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
LED PPB          49.2
```

LED Adjust Screen

Pressure

The Pressure screen, shown below, shows the fluorescence chamber pressure. The fluorescence chamber pressure is updated every second. This screen is used while adjusting the pressure transducer potentiometers.

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Pressure screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose Pressure

To use the Pressure screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
PRESSURE 753.4 mm Hg
```

Pressure Screen

Flow

The Flow screen, shown below, shows the sample flow. The sample flow reading is updated every second. This screen is used while the sample flow sensor potentiometers are adjusted. The potentiometer closest to the divider panel is the zero adjust potentiometer and the potentiometer farthest from the divider panel is the span potentiometer.

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

To display the Sample Flow screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose Sample Flow

To use the Sample Flow screen:

- ► This is a view only screen
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
FLOW        0.531 LPM
```

Sample Flow Screen

A/D Frequency

The A/D Frequency screen, shown below, displays the frequency of each of the 12 analog to digital (A/D) converters located on the A/D Board. Each A/D has a frequency range between 0 and 100,000 Hertz. This frequency range corresponds to a voltage range of 0 to -10 volts dc. See Appendix E, "Schematics" for the A/D Board schematic. The A/D converters are assigned as follows:

A/D Converter	Function
AN0	Lamp Voltage
AN1	Sample Flow
AN2	Spare
AN3	Spare
AN4	Spare
AN5	Permeation Oven Temperature
AN6	Permeation Gas Temperature
AN7	Pressure
AN8	Spare
AN9	PMT Voltage
AN10	Fluorescence Chamber Temperature
AN11	Internal Ambient Temperature

Table 3-2. A/D Converters

To display the A/D Frequency screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose A/D Frequency

To use the A/D Frequency screen:

- ► Use the ↑ and ↓ pushbuttons to increment/decrement the A to D number
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
A TO D FREQ          0
A TO D NUMBER     NONE

↑↓ INC/DEC
```

A/D Frequency Screen

Set Test Display

The Set Test Display screen, shown below, displays the contents of a given memory location. This screen is only useful to TEI service personnel.

To display the Set Test Display screen:

- ► From the Main Menu choose Service Mode
- ► From the Service Mode menu choose Set Test Display

To use the Set Test Display screen:

- ► Use the ↑ and ↓ pushbuttons to change the display mode
- ► Press **MENU** to return to the Service Mode menu
- ► Press **RUN** to return to the Run screen

```
SET TEST DISPLAY:
MODE 0     ADDR 0000
```

Set Test Display Screen

INTERNAL OPTION SWITCHES

The internal option switches are located on the Motherboard (near front panel), as shown in Figure 3-7 below. The function of each option switch is given in Table 3-4. These switches are used to activate hardware and software options.

CAUTION: Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

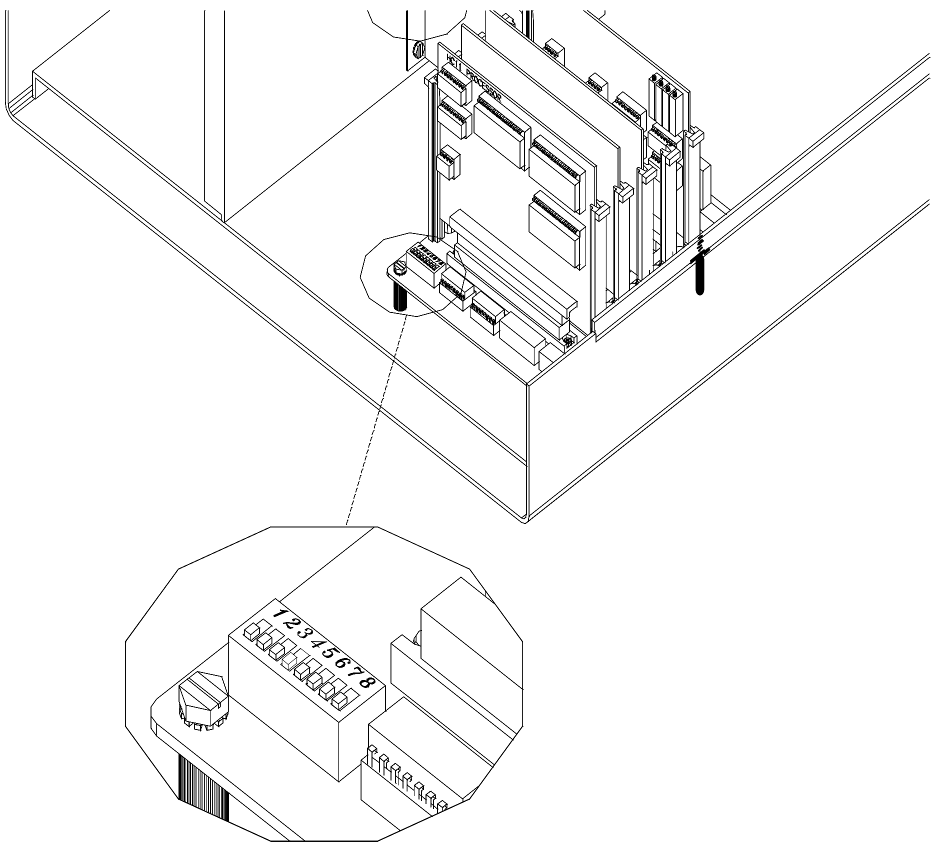


Figure 3-7. Location of Internal Option Switches

64P7192

Option Switch	Function
1	Remote
2	RS-232
3	Zero/Span and Sample Solenoid Valves
4	Double Range
5	Autorange
6	Lock
7	Permeation Span Source
8	Spare

Table 3-3. Option Switch Functions

Remote

Option switch 1 is on when a remote interface is installed, such as RS-232 or I/O activation.

RS-232

Option switch 2 is used to select between RS-232 and I/O activation. When option switch 2 is on, RS-232 is selected. When it is off, I/O activation is selected.

Zero/Span and Sample Solenoid Valves

Option switch 3 is on when the optional zero/span and sample solenoid valves are installed. For more information about the zero/span solenoid valves, see Chapter 9, “Optional Equipment.”

Double Range and Autorange

The double range (option switch 4) and autorange (option switch 5) switches are used to activate the single, dual, and autorange modes. The following table shows how each mode is activated. For more information about the single, dual, and autorange modes, see “Operating Modes,” earlier in this chapter.

Operating Mode	Option Switch 4	Option Switch 5
Single Range Mode	Off	On or Off
Dual Range Mode	On	Off
Autorange Mode	On	On

Table 3-4. Operating Mode Truth Table

Lock

When option switch 6 is on, instrument parameters are "locked" and can not be changed. This prevents any erroneous entry of instrument parameters. When option switch 6 is off, instrument parameters can be changed.

Permeation Span Source

Option switch 7 is on only when the optional permeation span source is installed.

Spare

This option switch is currently not used.

CHAPTER 4
CALIBRATION

The Model 43C Trace Level requires initial and periodic calibration according to the procedures described in this chapter. A quality control plan that allows the frequency and number of calibration points to be modified depending on calibration and zero/span check data should be implemented. Such a quality control program is essential to ascertain the accuracy and reliability of the air quality data collected. The data compiled for such a program might include items such as dates of calibration, atmospheric conditions, control settings and other pertinent data. For more detailed quality assurance guidelines, see the *Quality Assurance Handbook for Air Pollution Measurement Systems*, published by the U.S. EPA, Research Triangle Park, NC, 27711.

There are a number of conditions which should be met prior to a calibration or a zero/span check. First, the instrument should have at least 30 minutes to warm up and stabilize. Second, the range used during the calibration or zero/span check should be the same as that used during normal monitoring. Third, all operational adjustments to the instrument should be completed prior to calibration. Fourth, all parts of the gas flow system, such as sample lines, particulate filters, etc., which are used in normal monitoring should also be used during calibration. Finally, it is recommended that the recording devices and outputs used during normal monitoring be calibrated prior to the instrument calibration and that they be used during the calibration or the zero/span check.

ZERO GAS GENERATION

An SO_2-free air supply is required for the proper calibration and checkout of the analyzer. There are several methods that are acceptable to generate this zero gas. For more information about generating zero air, see Appendix D, "Standards for Trace Level Analyzers."

Commercial Heatless Air Dryers

Commercial heatless air dryers filled with a mixed bed of activated charcoal and a 13X molecular sieve have been found effective in removing SO_2 from compressed air. The use of this type of zero gas system is recommended when minimum maintenance is of prime importance. This system requires a source of compressed air. Refer to the manufacturer's recommendations for installation of such a system.

Absorbing Column

An absorbing column packed with activated charcoal (Part No. 4157) is acceptable for scrubbing SO_2 from ambient air. Ambient air is forced through a laboratory gas absorption column packed with the charcoal and the SO_2 is removed to acceptable levels. The charcoal should be changed at a minimum of every 6 months. It may be necessary to change the charcoal more frequently depending on local conditions.

CALIBRATION GAS GENERATION

A calibration gas system capable of providing accurate levels of SO_2 calibration gas between zero and 80% of the fullscale range is required. The calibration system must provide a flow rate of at least 0.8 LPM for an instrument with the standard flow (instruments with higher flow rates will require a higher minimum calibration system flow rate). All calibration gas should be derived from local or working standards (e.g., cylinders of compressed gas or permeation devices) that are certified as traceable to an NIST primary standard.

Cylinder Gas Dilution System

A cylinder gas dilution system, shown in Figure 4-1, can be constructed. All connections between components in the system should be made with glass, Teflon, or other non-reactive material.

The air flow controller should be capable of maintaining a constant air flow within $\pm$ 2% of the required flow rate. The SO_2 flow controller should be capable of maintaining constant SO_2 flows within $\pm$ 2% of the required flow rate. Ensure both flow controllers are properly calibrated. The pressure regulator for the standard SO_2 cylinder must have a non-reactive diaphragm and internal parts and a suitable delivery pressure.

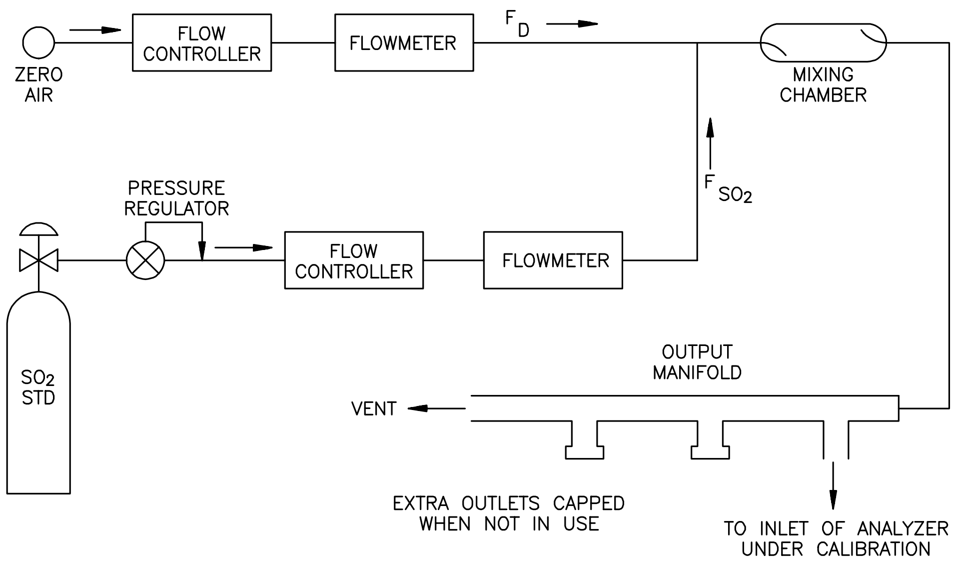


Figure 4-1. Cylinder Gas Dilution System

The exact SO_2 concentration is calculated from:

$$[SO_2]_{OUT} = \frac{[SO_2]_{STD} \times F_{SO_2}}{F_D + F_{SO_2}}$$

Where:

$[SO_2]_{OUT}$	=	diluted SO_2 concentration at the output manifold, ppm
$[SO_2]_{STD}$	=	concentration of the undiluted SO_2 standard, ppm
F_{SO2}	=	flow rate of the SO_2 standard corrected to 25^oC and 760 mm Hg
F_D	=	flow rate of the dilution air corrected to 25^oC and 760 mm Hg

Commercial Precision Dilution Systems Commercial precision dilution systems are available which reliably and accurately dilute a high concentration gas mixture to provide a reliable span gas. A high concentration of SO_2 in air is precisely diluted to the concentration range required. Thermo Environmental Instruments' Model 146 Multigas Calibration System is one such system for precision dilution.

Permeation Tube System

Permeation tube systems which precisely maintain a set temperature to within ±0.1°C and hold a zero air flow rate to within ± 0.5% can be used for generation of span gas. The flow rate of the permeation system must be at least 0.8 LPM for proper operation.

A permeation tube system, shown in Figure 4-2, can be constructed. All connections between components in the system should be made with glass, Teflon, or other non-reactive material.

The air flow controllers should be capable of maintaining a constant air flow within ± 2% of the required flow rate. Ensure all devices are properly calibrated and that all flows are corrected to 25°C and 1 atm.

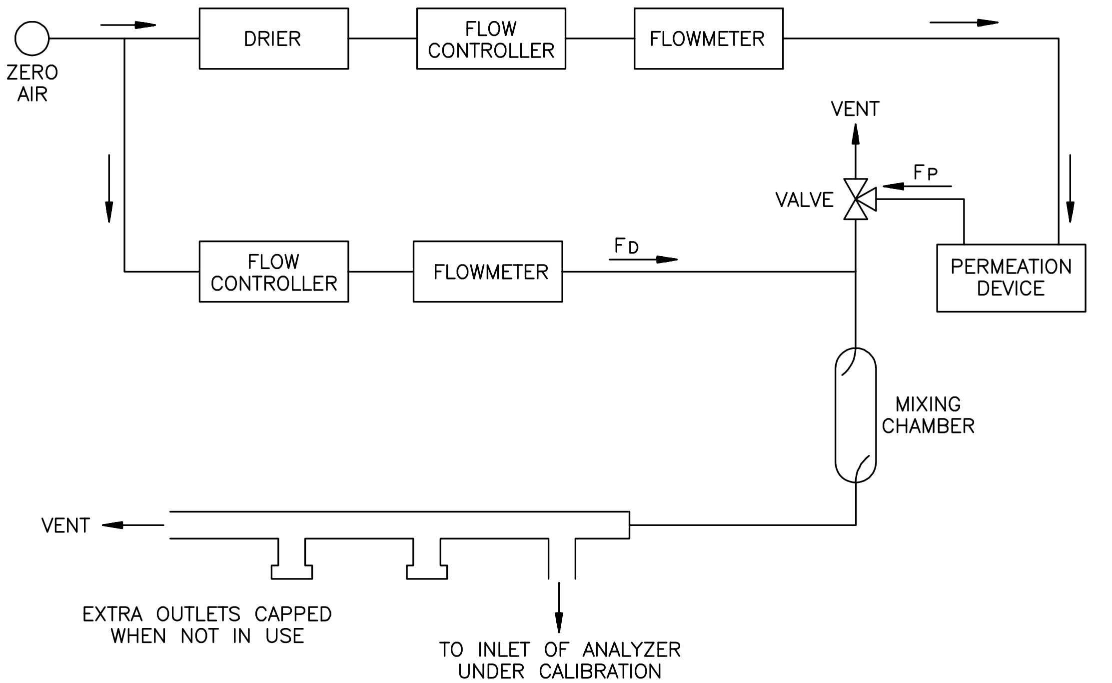


Figure 4-2. Permeation Tube System

The SO_2 output level is calculated from:

$$[SO_2]_{OUT} = \frac{P \times K}{F_T}$$

Where:

$[SO_2]_{OUT}$	=	SO_2 output concentration in ppm
P	=	permeation rate in ng/min
F_T	=	total flow rate of gas after mixing chamber ($F_P + F_D$), ml/min
K (SO_2)	=	constant for specific permeant, 0.382

Commercial Permeation Systems. Commercial permeation systems, such as Thermo Environmental Instruments' Model 146 Multigas Calibration System, are available for this requirement. Refer to the instrument instruction manual for more information.

MULTI-POINT CALIBRATION

Regulations require calibration when the instrument is newly installed, moved, repaired, interrupted for more than a few days, or when span or zero shift by more than 15%. If the instrument is equipped with the optional zero/span and sample valves, connect zero and span gas to the rear panel bulkheads labeled **ZERO** and **SPAN**. The **RUN** pushbutton is used to activate the zero and span valves. The lower left corner of the Run screen indicates which mode is active: zero, span, or sample.

> **NOTE**: All gas must be supplied to the instrument at atmospheric pressure, it may be necessary to employ an atmospheric bypass plumbing arrangement to accomplish this (see Figure 2-2). If a filter is used, all gas must enter the analyzer through the filter.

1. Connect a source of zero air to the **SAMPLE** bulkhead.

2. To ensure that the zero air is being measured at atmospheric pressure, check that the flow is about 0.5 LPM. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Flow and press **ENTER** to display the flow screen.

3. Press the **RUN** pushbutton to monitor the zero air reading and wait for the reading to stabilize.

4. Press the **MENU** pushbutton to display the Main Menu. Use ↓ pushbutton to move the cursor to Calibration and press **ENTER** to display the Calibration menu.

5. Press **ENTER** to select Calibrate Zero. The Calibrate Zero screen appears. The first line of the display shows the current SO_2 reading. Press **ENTER** to set the SO_2 reading to zero. The lower left corner of the display flashes the message "SAVING PARAMETER(S)" and the SO_2 reading is added to the background correction. Press the **MENU** pushbutton to return to the Calibration menu. Record the stable zero air reading as Z_{SO2}.

6. Connect a source of calibration gas to the **SAMPLE** bulkhead. The calibration gas should be about 80% of the fullscale range.

7. To ensure that the calibration gas is being measured at atmospheric pressure, check that the flow is about 0.5 LPM.

8. Sample the calibration gas and wait for the instrument reading to stabilize.

9. Use the ↓ pushbutton to move the cursor to Calibrate Span and press **ENTER** to display the Calibrate span screen. The first line of the display shows the current SO_2 reading. The second line of the display shows the current range. The third line of the display is where the calibration gas concentration is entered. To enter the calibration gas concentration, use the ← and → pushbuttons to move the cursor left and right. Use the ↑ and ↓ pushbuttons to increment and decrement the digit. Press the **ENTER** pushbutton to calibrate the analyzer to the SO_2 calibration gas. The lower left corner of the display flashes the message "SAVING PARAMETER(S)" and the corrected SO_2 reading is displayed. Press the **RUN** pushbutton to return to the Run screen. The SO_2 recorder response will equal:

$$\frac{[SO_2]_{OUT}}{URL} \times 100 = Z_{SO_2}$$

Where:

URL = upper range limit of the analyzer's operating range

Z_{SO2} = analyzer response to zero air, % fullscale

10. Generate five SO_2 concentrations equally spaced between zero and the concentration above. Record instrument reading for each concentration after allowing time for both gas generation system and instrument to stabilize. Plot a graph of instrument readings against the SO_2 concentrations generated. This is the instrument calibration curve. All future measurements should be interpreted using this curve.

MULTI-POINT CALIBRATION IN DUAL/AUTORANGE MODE

Regulations require calibration when the instrument is newly installed, moved, repaired, interrupted for more than a few days, or when span or zero shift by more than 15%. If the instrument is equipped with the optional zero/span and sample valves, connect zero and span gas to the rear panel bulkheads labeled **ZERO** and **SPAN**. The **RUN** pushbutton is used to activate the zero and span valves. The lower left corner of the Run screen indicates which mode is active: zero, span, or sample.

> **NOTE**: All gas must be supplied to the instrument at atmospheric pressure, it may be necessary to employ an atmospheric bypass plumbing arrangement to accomplish this (see Figure 2-2). If a filter is used, all gas must enter the analyzer through the filter.

1. Connect a source of zero air to the **SAMPLE** bulkhead.

2. To ensure that the zero air is being measured at atmospheric pressure, check that the flow is about 0.5 LPM. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Flow and press **ENTER** to display the flow screen.

3. Press the **RUN** pushbutton to monitor the zero air reading and wait for the reading to stabilize.

4. Press the **MENU** pushbutton to display the Main Menu. Use ↓ pushbutton to move the cursor to Calibration and press **ENTER** to display the Calibration menu.

5. Press **ENTER** to select Calibrate Zero. The Calibrate Zero screen appears. The first line of the display shows the current SO_2 reading. Press **ENTER** to set the SO_2 reading to zero. The lower left corner of the display flashes the message "SAVING PARAMETER(S)" and the SO_2 reading is added to the background correction. Press the **MENU** pushbutton to return to the Calibration menu. Record the stable zero air reading as Z_{SO2}.

6. Connect a source of calibration gas to the **SAMPLE** bulkhead. The calibration gas should be about 80% of the high fullscale range.

7. To ensure that the calibration gas is being measured at atmospheric pressure, check that the flow is about 0.5 LPM.

8. Sample the calibration gas and wait for the instrument reading to stabilize.

9. Use the ↓ pushbutton to move the cursor to Calibrate HI Span and press **ENTER** to display the Calibrate HI Span screen. The first line of the display shows the current SO_2 reading. The second line of the display shows the current high range. The third line of the display is where the high calibration gas concentration is entered. To enter the high calibration gas concentration, use the ← and → pushbuttons to move the cursor left and right. Use the ↑ and ↓ pushbuttons to increment and decrement the digit. Press the **ENTER** pushbutton to calibrate the analyzer to the high SO_2 calibration gas. The lower left corner of the display flashes the message "SAVING PARAMETER(S)" and the corrected SO_2 reading is displayed. Press the **MENU** pushbutton to return to the Calibration menu. The SO_2 recorder response will equal:

$$\frac{[SO_2]_{OUT}}{URL} \times 100 = Z_{SO_2}$$

Where:

URL = upper range limit of the analyzer's operating range

Z_{SO2} = analyzer response to zero air, % fullscale

10. Generate five SO_2 concentrations equally spaced between zero and the concentration above. Record instrument reading for each concentration after allowing time for both gas generation system and instrument to stabilize. Plot a graph of instrument readings against the SO_2 concentrations generated. This is the instrument calibration curve. All future measurements should be interpreted using this curve.

11. Connect a source of calibration gas to the **SAMPLE** bulkhead. The calibration gas should be about 80% of the low fullscale range.

12. Use the ↓ pushbutton to move the cursor to Calibrate LO Span and press **ENTER** to display the Calibrate LO Span screen. The first line of the display shows the current SO_2 reading. The second line of the display shows the current low range. The third line of the display is where the low calibration gas concentration is entered. To enter the low calibration gas concentration, use the ← and → pushbuttons to move the cursor left and right. Use the ↑ and ↓ pushbuttons to increment and decrement the digit. Press the **ENTER** pushbutton to calibrate the analyzer to the low SO_2 calibration gas. The lower left corner of the display flashes the message "SAVING PARAMETER(S)" and the corrected SO_2 reading is displayed. Press the **MENU** pushbutton to return to the Calibration menu.

13. Generate five SO_2 concentrations equally spaced between zero and the concentration above. Record instrument reading for each concentration after allowing time for both gas generation system and instrument to stabilize. Plot a graph of instrument readings against the SO_2 concentrations generated. This is the instrument calibration curve. All future measurements should be interpreted using this curve.

ZERO/SPAN CHECK/SPAN CHECK

The zero/span check procedure is normally performed before and after a sampling period and any time a quick check of the accuracy of the instrument is required. Normally, zero and span are checked daily. As experience is gained with the analyzer, the frequency of these checks can be adjusted accordingly. The span gas concentration used in the span check should be between 70% and 90% of the fullscale range. The zero and span drift should be measured and recorded prior to making any adjustments.

If the instrument is equipped with the optional zero/span and sample valves, connect zero and span gas to the rear panel bulkheads labeled **ZERO** and **SPAN**. The **RUN** pushbutton is used to activate the zero and span valves. The lower left corner of the Run screen indicates which mode is active: zero, span, or sample.

> **NOTE**: All gas must be supplied to the instrument at atmospheric pressure, it may be necessary to employ an atmospheric bypass plumbing arrangement to accomplish this (see Figure 2-2). If a filter is used, all gas must enter the analyzer through the filter.

1. Connect a source of zero air to the **SAMPLE** bulkhead.

2. To ensure that the zero air is being measured at atmospheric pressure check that the flow is about 0.5 LPM. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Sample Flow and press **ENTER** to display the flow screen.

3. Press the **RUN** pushbutton to monitor the zero air reading and wait for the reading to stabilize.

4. Record the measured SO_2 value as the zero drift since the last adjustment. If the zero has changed by more than ± 1.5 ppb, it is recommended that a new calibration be performed.

5. Connect span gas to the **SAMPLE** bulkhead. The span gas should be about 80% of the fullscale range.

6. To ensure that the span gas is being measured at atmospheric pressure check that the flow is about 0.5 LPM.

7. Press the **RUN** pushbutton to monitor the span gas reading and wait for the reading to stabilize.

8. Record the difference between the measured SO_2 value and the actual SO_2 span concentration used. This is the span drift since the last adjustment. If the calibration has changed by more than ± 10%, a new calibration should be performed.

CHAPTER 5
PREVENTIVE MAINTENANCE

To ensure proper operation of the Model 43C Trace Level, the maintenance procedures described in this chapter should be performed every six months.

SPARE PARTS

Table 5-1 lists recommended spare parts.

Part Number	Description
8919	Capillary - 13 mil long (~.5 L/min flow rate) standard
4125	Capillary - 20 mil long (~1 L/min flow rate)
4800	Capillary O-Ring
8550	Pump - 110 volts
8551	Pump - 220 volts
8709	Pump - specify voltage and frequency
8606	Pump repair kit
13399	Model 43C Trace Level Instruction Manual
4158	Charcoal (pound)
8666	Flash lamp
60100	Particulate filter assembly
4509	Fuse (115V) T, 2A, 250V
14008	Fuse (220V) T, 0.8A, 250 V

Table 5-1. Recommended Spare Parts

VISUAL INSPECTION AND CLEANING

The Model 43C Trace Level should be inspected occasionally for obvious visible defects, such as loose connectors, loose fittings, cracked or clogged Teflon lines, and excessive dust or dirt accumulation. Dust and dirt can accumulate in the instrument and can cause overheating or component failure. Dirt on the components prevent efficient heat dissipation and may provide conducting paths for electricity. The best way to clean the inside of the instrument is to first carefully vacuum all accessible areas and then blow away the remaining dust with low-pressure compressed air. Use a soft paint brush or cloth to remove stubborn dirt.

FAN FILTER INSPECTION AND CLEANING

Under normal use, the filter over the instrument fan located on the rear panel of the instrument should be cleaned and reconditioned at six-month intervals. If the instrument is operated in excessively dirty surroundings, this procedure should be instituted on a more frequent schedule.

1. Remove the filter cover by gently pulling it off the fan guard.
2. Flush the filter with warm water and let dry (a clean, oil-free air purge will help with the drying process).
3. Re-install filter and filter cover.

CAPILLARY INSPECTION AND REPLACEMENT

To ensure that the pressure reducing capillary does not plug or impair the flow of sample gas through the instrument, it should be inspected approximately every six months. To remove the capillary, follow the procedure below:

1. Wear an antistatic wrist strap that is properly connected to earth ground. See "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Locate the capillary holder and remove the cap nut.
4. Remove the glass capillary (long - 13 mil) and O-Ring.
5. Check the capillary for particulate deposits within the bore. Clean or replace the capillary (Part No. 8919) if particulate deposits are present.
6. Check the O-Ring (Part No. 4800) for cuts or abrasions and replace it if either are present.
7. Replace the capillary in the holder, making sure the O-Ring is around the capillary before inserting it into the holder.
8. Finger-tighten the holder cap nut over the capillary enough to ensure a tight seal.
9. Re-install the instrument cover.

SAMPLE PARTICULATE FILTER INSPECTION

If a sample pre-filter is used, it should be inspected regularly for excessive dust and particulates, which restrict flow. If necessary, replace the sample filter.

FLOW CHECK

A flow rate of about 0.5 LPM should be observed for a standard instrument, if a flow rate of less than 0.35 LPM is observed, the following leak test procedure below should be performed:

1. Block the bulkhead labeled **SAMPLE** on the rear panel with a leak-tight cap.
2. Wait two minutes.
3. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics, and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Sample Flow and press **ENTER** to display the flow screen. The flow reading should now read zero flow and the pressure reading should be less than 180 mm Hg. If not, check to see that all fittings are tight, and that none of the input lines are cracked or broken.

LAMP VOLTAGE CHECK

The Model 43C Trace Level is equipped with a lamp voltage control circuit, which automatically corrects for the degradation of the flash lamp with age. However, after several years of use, the lamp may have degraded to the point that it is being driven with the maximum voltage (1200 V) that the power supply can deliver.

To display the lamp voltage, press the **MENU** pushbutton from the Run screen to display the Main Menu. Use the ↓ pushbutton to move the cursor to Diagnostics, and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Lamp Intensity, and press **ENTER** to display the lamp intensity screen. If this voltage is at 1200 V, it is necessary to either replace the lamp or adjust the lamp voltage control circuit. For more information about replacing the lamp or adjusting the lamp voltage control circuit, see Chapter 7, "Servicing."

CHAPTER 6
TROUBLESHOOTING

The Model 43C Trace Level has been designed to achieve a high level of reliability. Only premium components are used, thus complete failure is rare. In the event of problems or failure, the troubleshooting guidelines presented in this chapter should be helpful in isolating the fault(s). The Service Department at Thermo Environmental can also be consulted in the event of problems at (508) 520-0430. In any correspondence with the factory, please note both the serial number and program number of the instrument.

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component. For more information about appropriate safety precautions, see Chapter 7, "Servicing."

TROUBLESHOOTING GUIDE

MALFUNCTION	POSSIBLE CAUSE	ACTION
Does not start up	No power	Check that the instrument is plugged into the proper source (110 or 220 volts)
		Check instrument fuse
	Power supply	Check voltages from power supply
	Digital electronics	Check that all boards are seated properly
		Replace boards one at a time with spare boards to isolate the faulty board.
No response to gas	Bad calibration	Ensure proper calibration

No response to gas (cont.)	Bad span gas	Verify quality of span gas
	Flasher power supply	Check all voltages and test points
	Lamp trigger pak	Replace with known good trigger pak to isolate bad part
	Lamp	Remove lamp and socket from flash holder by loosening the single set screw. The lamp flash should be clearly visible at 20 yards distance in a well-lit room.
	PMT high voltage power supply	Check voltage on high voltage power supply connector, this voltage should be about -400 and -1200 volts (violet is positive)
	PMT	Replace with known good PMT to see if the PMT is the problem
	Input board	Check voltages and test point
	Digital electronics	Replace board one at a time with spare boards to isolate the faulty board
	Bad pump	Check pump vacuum
	Capillary blocked	Clean or replace

Excessive response time	Partially blocked capillary	Clean or replace
Calibration drift	Non-consistent SO_2 calibration source	Verify SO_2 generation system or source
	Faulty zero air used in calibration system	Check zero air generation system)
	Temperature control board or thermistor	For proper operation the temperature control board LED should be blinking
Zero drift	Zero air	Check zero air generation system
Excessive noise	Noisy recorder	Check recorder for electrical noise pickup
	Input board	Replace with known good input board to see if it is the problem
	Defective or low sensitivity PMT	Install known good PMT and check performance
Spikes in recorder output	Improper grounding of instrument or recorder	Ensure instrument and recorder are properly grounded through line cord
No output voltage	Jumper missing	Replace jumper on D/A Board

No output voltage (cont.)	D/A board	Replace with a known good D/A board to see if the board is the problem
Inaccurate output voltage	Analog output needs adjustment	Perform analog output adjustment as described in Chapter 4, "Calibration"
	D/A board	Run DAC ramp as described in Chapter 3, "Operation"
Low flow	Capillary blocked	Clean or replace
	Internal instrument leak	Perform leak test
Unstable span	Internal instrument leak	Perform leak test
	PMT high voltage power supply	Check voltage on high voltage power supply connector, this voltage should be about -400 and -1200 volts (violet is positive)
	Flasher lamp	Replace with known good lamp to see if the lamp is the problem
High scattered light	Zero air supply	Check zero air generation system
	Low pump vacuum	Perform leak test. If leak test fails to discover leak, rebuild or replace pump

Low lamp intensity	Flasher lamp	Check that the lamp and trigger pak are securely fastened
Flow meter fluctuations	Dirty pump diaphragm	Clean or replace
	Capillary blocked	Clean or replace
	Clogged Teflon line	Inspect all lines
Span factor outside acceptable limits of 0.5 - 2.0	Bad span gas	Verify quality of span gas
	System leak	Perform leak test
	Insufficient calibrator flow	Verify calibrator is providing a flow of at least 0.8 LPM (for standard instrument)

CHAPTER 7
SERVICING

This chapter explains how to replace the Model 43C Trace Level subassemblies. Fault location is accomplished in the preceding chapters of "Preventive Maintenance" and "Troubleshooting." This chapter assumes that a subassembly has been identified as defective and needs to be replaced. For additional service assistance, see "Servicing Locations" later in this chapter.

SAFETY PRECAUTIONS

Some internal components can be damaged by the discharge of static electricity. To avoid damaging internal components, follow these precautions when performing any service procedure:

- Wear an antistatic wrist strap that is properly connected to earth ground (note that when the analyzer is unplugged, the chassis is not at earth ground)
- If an antistatic wrist strap is not available, be sure to touch a grounded metal object before touching any internal components
- Handle all printed circuit boards by the edges
- Carefully observe the instructions in each procedure

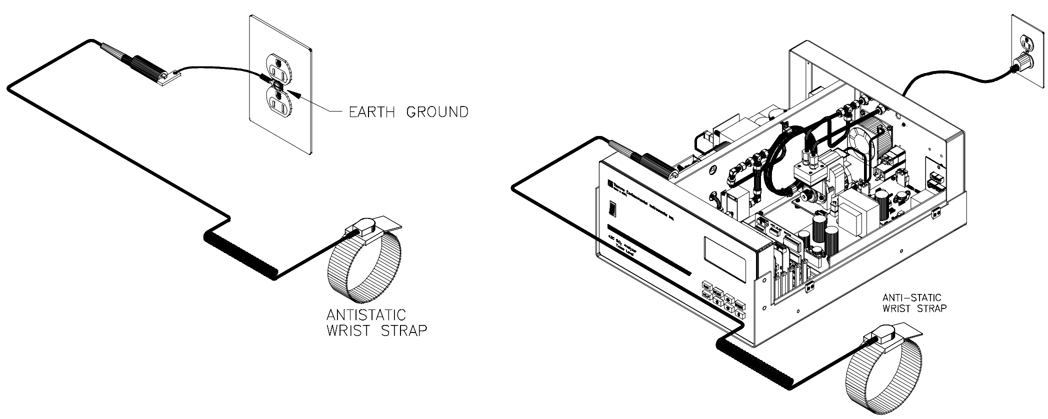


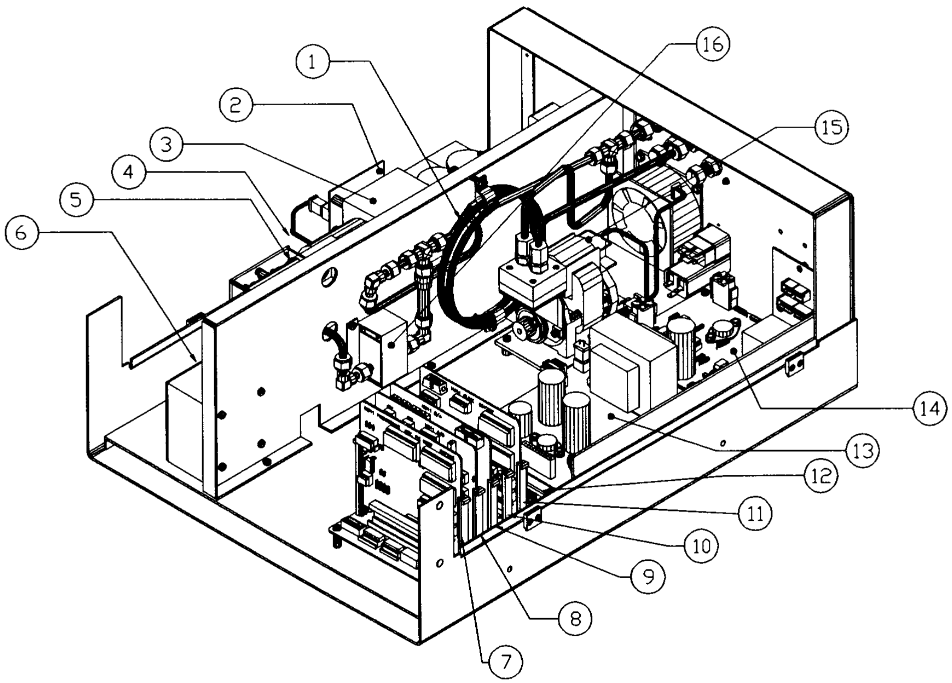
Figure 7-1. Properly Grounded Antistatic Wrist Strap 64P263/57P7127

REPLACEMENT PARTS LISTS

Table 7-1 lists the part numbers of the major subassemblies in the Model 43C Trace Level. Refer to Figure 7-2 to identify their location.

Part Number	Description
9829	Motherboard
9837	Processor Board
8943	Analog/Digital Board
9839	Digital/Analog Board
8949	Power Supply Board
8774	Trigger Pak
8884	Flash Intensity Board
10996	Flasher Supply Board
8951	Input Board
8765	Temperature Control Board
9843	C-Link Board
8919	Capillary - 13 mil
4800	Capillary O-ring
8666	Flash Lamp
8606	Pump Rebuild Kit
8550	Pump 110V
8551	Pump 220V

Table 7-1. Replacement Parts



NO.	DESCRIPTION
1	HYDROCARBON KICKER
2	TEMPERATURE CONTROL BOARD
3	OPTICAL BENCH
4	PRESSURE TRANSDUCER (NOT VISIBLE)
5	INPUT BOARD
6	PMT HIGH VOLTAGE POWER SUPPLY
7	PROCESSOR BOARD
8	A/D BOARD
9	D/A BOARD
10	OPTIONAL BOARD, E.G. I/O BOARD
11	C-LINK BOARD
12	MOTHER BOARD
13	POWER SUPPLY BOARD
14	FLASHER SUPPLY BOARD
15	PUMP
16	FLOW SENSOR

Figure 7-2. Model 43C Trace Level Component Layout

> **NOTE**: Power should be removed from the instrument before any servicing is performed.

PUMP REBUILDING

Equipment Required:
- Pump Repair Kit
- Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Loosen fittings and remove both lines going to the pump.
5. Remove four screws from the top plate, remove the top plate, flapper valve, and the bottom plate (see Figure 7-3).
6. Remove clamping disk holding diaphragm and Teflon protection wafer onto clamping rod, remove both diaphragm and Teflon wafer.
7. Assemble pump by following above procedure in reverse, making sure not to over-tighten clamping disk, and to have Teflon side of diaphragm facing up and that the flapper valves cover the holes of the top and bottom plate.
8. Re-install the instrument cover.
9. Check that the flow reads about 0.5 LPM when power is turned on.

PUMP REPLACEMENT

Equipment Required:
- 110 volt Pump
- 220 volt Pump
- Nutdriver
- Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Disconnect power line of pump from power supply.
5. Loosen fittings and remove both lines going to the pump.
6. Remove four screws holding pump mounting plate to floor plate.
7. Remove two screws holding pump to mounting plate.
8. Install new pump by following above procedure in reverse.
9. Re-install the instrument cover.

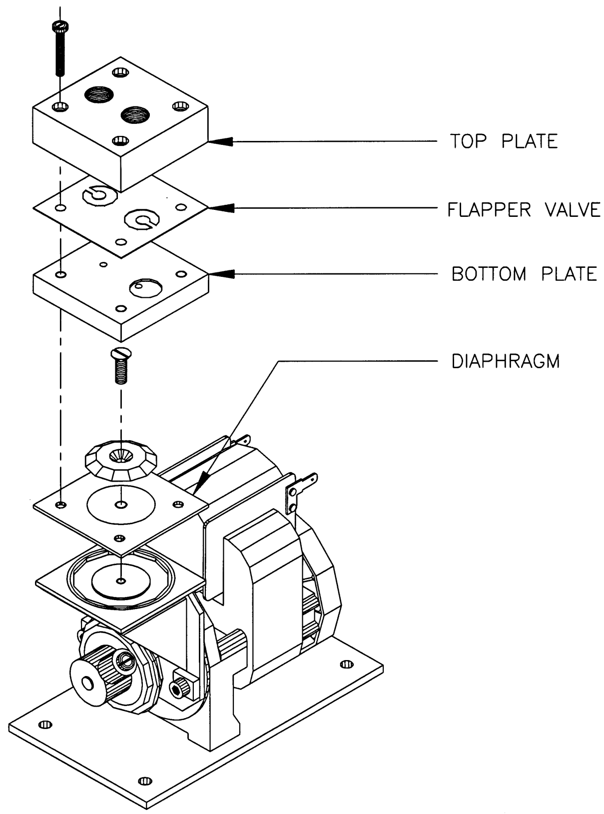


Figure 7-3. Pump Assembly

93P737

PMT REPLACEMENT

Equipment Required:
PMT
Allen Wrench - 5/32"
Nutdriver - 1/4"
Screwdriver

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Locate PMT housing. Disconnect the two-pin connector from the PMT to the PMT high voltage supply.

5. Disconnect the signal cable from the Input Board.
6. Use 5/32" Allen wrench to remove the two screws securing PMT housing.
7. Use screwdriver and remove the three screws from the PMT cover.
8. With care slide the cover out.
9. Use 1/4" nutdriver and remove the two screws from at top and bottom of PMT base.
10. Pull the socket and tube out, and replace tube with new one.
11. Follow the above procedure in reverse, make sure all connectors and screws are tight.
12. Re-install the instrument cover.

FLASH LAMP REPLACEMENT

Equipment Required:
Flash Lamp
Screwdriver

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Locate the lamp housing and trigger pak (see Figure 7-3).
5. Disconnect the three-pin connector from the flasher supply board.
6. Loosen the single screw on the lamp housing.
7. Pull out trigger pak and lamp from lamp housing.

CAUTION: Do not touch lamp front window with hands, if this happens wash lamp with laboratory cleaning solution and dry before replacement.

8. Insert new lamp in socket.
9. Follow the above procedure in reverse, make sure all connectors and screws are tight.
10. Follow “Lamp Voltage Adjustment” procedure below.
11. Re-install the instrument cover.

LAMP VOLTAGE ADJUSTMENT

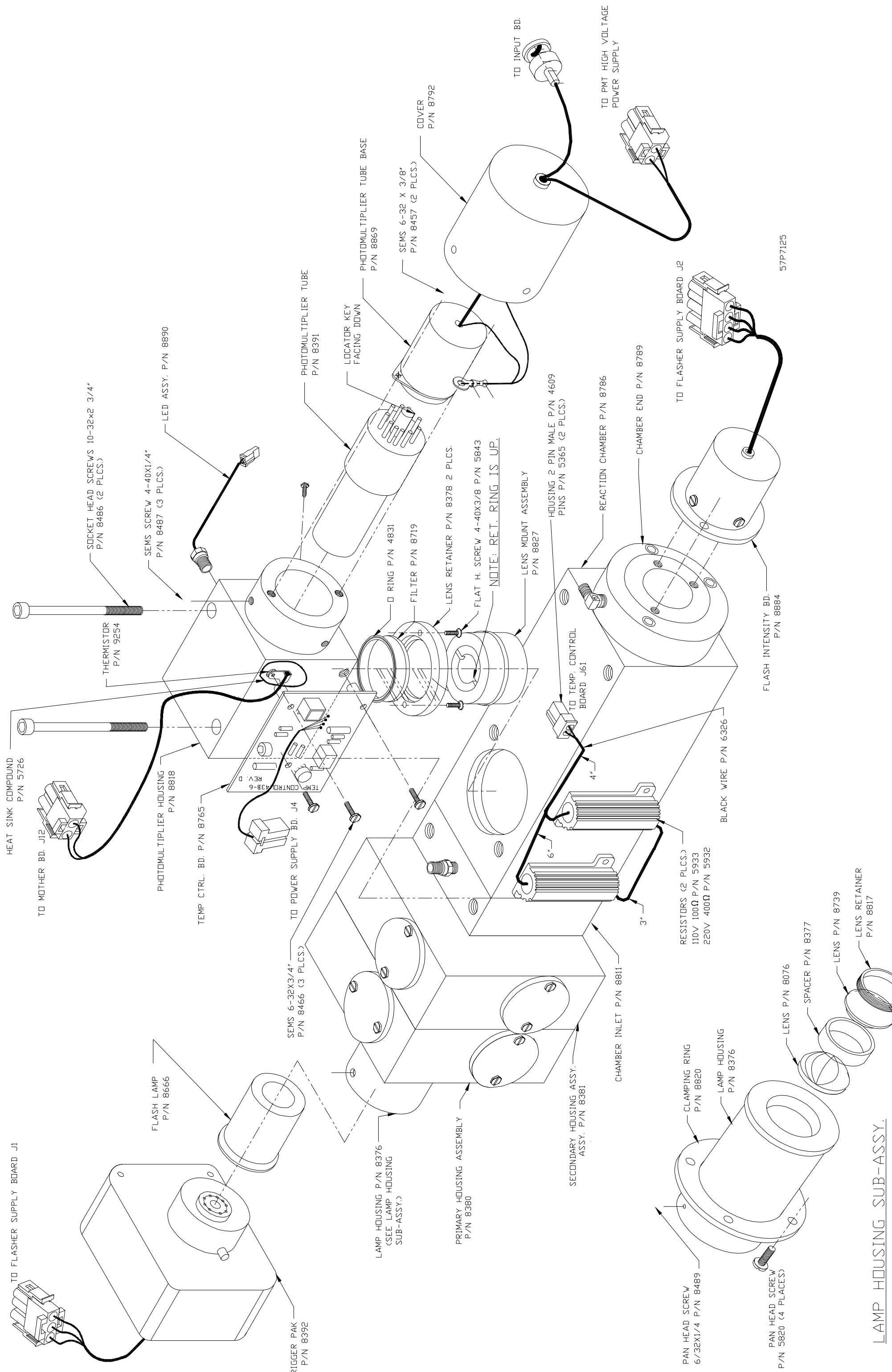
Equipment Required:
Screwdriver

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Locate the lamp voltage adjustment potentiometer (R28) on the lamp power supply board.
4. Access the Diagnostic menu to display the current lamp voltage.
5. Using a small screwdriver, turn the lamp voltage adjustment potentiometer until the lamp voltage is back to 800 volts.
6. Since the light intensity will now be less than it had been before the adjustment, the photomultiplier gain will now have to be adjusted proportionately. A calibration should therefore be performed at this time.
7. Re-install the instrument cover.

FLASH INTENSITY BOARD REPLACEMENT

Equipment Required:
Flash Intensity Board
Allen Wrench - 5/32"
Screwdriver

1. Wear an antistatic wrist strap, see “Safety Precautions,” earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Remove the four screws securing the optical bench to the floor plate with 5/32" Allen wrench.
5. Lift the optical bench from the floor plate to gain access to the Flash Intensity Board (see Figure 7-4).
6. Remove the three screws holding the flash intensity assembly to the reaction chamber.
7. Install new Flash Intensity Board by following the above procedure in reverse.
8. Re-install the instrument cover.



57P7125

Figure 7-4. Optical Bench Assembly

TEMPERATURE CONTROL BOARD REPLACEMENT

Equipment Required:
Temperature Control Board
Nutdriver - 1/4"

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Unplug J61 on the temperature control board (see Figure 7-4).
5. Unplug J4 on the dc power supply board.
6. Remove three screws with a 1/4" nutdriver.
7. Cut the tie-wrap holding thermistor leads to standoff.
8. Install new temperature control board by following the above procedure in reverse.
9. Re-install the instrument cover.

DC POWER SUPPLY BOARD REPLACEMENT

Equipment Required:
DC Power Supply
Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Disconnect all plug-in connections from both the dc power supply and flasher supply boards.
5. Remove the power supply board base, which holds the power supply and the flasher supply boards, by removing the four screws securing it to the instrument floor plate.
6. Remove the two remaining corner screws from the dc power supply board.
7. Remove the two screws holding down the transformer on the dc power supply.
8. Remove one nut located near U1 on the dc power supply board.
9. Carefully lift the power supply board from the power supply board base.
10. Replace power supply board. Be sure the leads of U1 are fully inserted into the proper sockets on the bottom side of the power supply board.
11. Follow the above procedure in reverse, making sure all screws are tight and all connectors are properly plugged in.
12. Re-install the instrument cover.

FLASHER SUPPLY BOARD REPLACEMENT

Equipment Required:
Flasher Supply Board
Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Unplug the three connectors.
5. Remove five screws, one in each corner and one in the center.
6. Install new flasher supply board by following the above procedure in reverse.
7. Re-install the instrument cover.

PMT HIGH VOLTAGE POWER SUPPLY REPLACEMENT

Equipment Required:
PMT High Voltage Power Supply
Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.
2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.
4. Remove the four screws that hold the PMT high voltage power supply to the divider panel.
5. Disconnect both PMT high voltage power supply connectors.
6. Install new PMT high voltage power supply by following the above procedure in reverse.
7. The PMT gain will now have to be adjusted.

INPUT BOARD REPLACEMENT

Equipment Required:
Input Board
Screwdriver

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.

2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Release four latch fasteners and remove instrument cover.

4. Disconnect the signal cable from the Input Board.
5. Remove three screws from the Input Board cover.
6. Remove four screws securing Input Board to divider panel.
7. Install new Input Board by following the above procedure in reverse.
8. Re-install the instrument cover.

ANALOG OUTPUT ADJUSTMENT

The analog outputs need only be adjusted if the concentration value on the front panel display disagrees with the analog outputs. To see if the analog outputs need to be adjusted, compare the front panel display to the analog output voltage. If they differ by more than 1%, then the analog outputs should be adjusted. This procedure should only be performed by an instrument service technician.

1. Wear an antistatic wrist strap that is properly connected to earth ground, see “Safety Precautions,” earlier in this chapter for more information.
2. Remove the instrument cover.

3. From the Run screen, press the **MENU** pushbutton to display the Main Menu. Use the □ pushbutton to move the cursor to Diagnostics, and press **ENTER** to display the Diagnostics menu. Use the ↓ pushbutton to move the cursor to Test Analog Outputs, and press **ENTER**. The Test Analog Output screen appears as shown below.

```
SET OUTPUTS TO:
>ZERO
 FULL SCALE
 RAMP
```

Test Analog Outputs Menu

4. Press **ENTER** to select Zero. The zero screen appears as shown below. Using a small screwdriver, adjust potentiometer R1 and R3 on the D/A Board until the analog outputs read 0 volts. Press the **MENU** pushbutton to return to the Test Analog Outputs menu.

```
OUTPUTS          0.0 %
↑↓ INC/DEC
```

Zero Analog Outputs Screen

5. Press the ↓ pushbutton to move the cursor to Fullscale and press **ENTER**. The fullscale screen appears as shown below. Using a small screwdriver, adjust potentiometer R2 and R4 on the D/A Board until the analog outputs read 10 volts (standard instrument). Press the **MENU** pushbutton to return to the Test Analog Outputs menu.

```
OUTPUTS        100.0 %
↑↓ INC/DEC
```

Fullscale Analog Outputs Screen

6. Repeat the above steps to ensure the adjustments are accurate.
7. Re-install the instrument cover.

PRESSURE TRANSDUCER ADJUSTMENT

Equipment Required:
- Vacuum Pump
- Screwdriver

> **CAUTION:** Some internal components can be damaged by small amounts of static electricity. A properly grounded antistatic wrist strap must be worn while handling any internal component.

1. Wear an antistatic wrist strap, see "Safety Precautions," earlier in this chapter for more information.

2. Turn the instrument off, unplug the power cord, and remove the instrument cover.
3. Disconnect the tubing from the pressure transducer and connect a vacuum pump known to produce a vacuum less than 1 mm Hg.
4. From the Run screen, press **MENU** to display the Main Menu. Use the ↓ pushbutton to move the cursor to Service menu. Press **ENTER** to display the Service menu. Use the pushbutton to move the cursor to Pressure. Press **ENTER** to display the pressure reading.
5. Adjust the zero potentiometer on the pressure transducer for a reading of zero mm Hg.
6. Disconnect the vacuum pump. The display should read the current local barometric pressure. If this value does not agree with a known accurate barometer, adjust the span potentiometer.
7. Reconnect the tubing to the pressure transducer.
8. Re-install the instrument cover.

Note that if the expected pressure changes are small (i.e., the only changes expected are barometric weather changes and not altitude changes) an error in the zero setting will not introduce a measurable error if the span is adjusted correctly. Thus if only a barometer is available, and not a vacuum pump, only adjust the span. If a barometer is not available, a rough check could be made as follows. Obtain the current barometric pressure from the local weather station or airport. Since these pressures are usually reported corrected to sea level, it might be necessary to correct to local pressure by subtracting 0.027 mm Hg per foot of altitude. Do not try to calibrate the pressure transducer unless the pressure is known accurately. It is possible for the atmospheric barometric pressure from room to room or in a building to be different from the outside atmospheric pressure as a result of the positive pressure developed by the air-conditioning and/or heating systems.

TEMPERATURE SENSOR ADJUSTMENT

Equipment Required:

Calibrated Thermometer or 10KΩ ± 1% Resistor
Screwdriver

In order to calibrate the temperature sensor, tape the thermistor plugged into the Motherboard to a calibrated thermometer. Adjust the **GAIN** potentiometer on the Analog to Digital Board until the internal temperature reading agrees with the value on the calibrated thermometer. Since the thermistors used in the Model 43C Trace Level are interchangeable to an accuracy of ± 0.2°C, and have a value of 10K ohms at 25°C, an alternate procedure is to connect an accurately known 10K resistor to the thermistor input on the Motherboard, and adjust the **GAIN** potentiometer for an internal temperature reading of 25°C. Note that a 1°C change corresponds to a ± 5% change in resistance, thus this alternative procedure can be quite accurate as a check; however, it clearly is not NIST traceable.

FUSE REPLACEMENT

Equipment Required:
115V T, 2A, 250V
220V T, 0.8A, 250V

1.Disconnect power to instrument.
2.Remove fuse drawer, located on the AC power connector.
3.Replace both fuses, if either is blown.
4.Insert fuse drawer and reconnect power cord.

SERVICE LOCATIONS

For additional assistance, Environmental Instruments Division has service available from exclusive distributors worldwide. Contact one of the phone numbers below for product support and technical information.

866-282-0430 Toll Free
508-520-0430 International

CHAPTER 8
THEORY OF OPERATION

In order to better understand the operation of the Model 43C Trace Level, a general knowledge of the electronics, software, and subassemblies is necessary.

ELECTRONICS

The electronics can be broken down into the following subassemblies:

- DC Power Supply
- Flasher Supply Board
- Flash Intensity Board
- Input Board
- Temperature control Board
- Trigger Pak
- Microprocessor System

A brief description of each follows. Note that all the electrical schematics are given in Appendix E, “Schematics.”

DC Power Supply

The DC Power Supply outputs the regulated and unregulated dc voltages necessary to operate the digital electronics, the Flasher Supply Board, Flash Intensity Board, Input Board, Trigger Pak, and Temperature Control Board. It outputs +24 volts unregulated and ±15 volts and +5 volts regulated. The main transformer can be configured for use with either 110 or 220 volts ac. The power supply board also contains the circuitry for driving the optional zero/span and sample solenoid valves.

Flasher Supply Board

The Flasher Supply Board provides the necessary high voltage for the flash lamp and also contains the lamp voltage control circuit. As the light output from the lamp falls, the lamp voltage circuit drives the lamp with a higher voltage, thereby keeping the light intensity constant. The lamp voltage is factory set at 800 volts, but after several years of use, the lamp may have degraded to the point that is being driven with the maximum voltage (1200 volts) that the power supply can deliver.

The lamp intensity signal, coming from the Flash Intensity Board, is fed to a precision sample and hold amplifier. The output of the sample and hold amplifier is fed to both a comparator (U6) and to a voltage to frequency converter (U7). The comparator compares the actual lamp intensity to a reference signal defined by R28 (INT ADJ). The difference between the actual and reference intensity signals is used to control the lamp voltage. The output of the voltage to frequency converter is sent to the microprocessor board.

A timer (U5) generates a square wave, which drives Q5 and then the step-up transformer to produce the flash lamp high voltage.

Flash Intensity Board

The Flash Intensity Board amplifies the lamp intensity signal detected by the photodetector. The output of the photodetector (R1228) is integrated by C1 and R3 and the fed to an op-amp (IC1). The output of the op-amp is sent to the Flasher Supply Board to be used to control the lamp voltage.

Input Board

A photomultiplier tube (PMT) transforms the light intensity into a current. The Input Board contains a preamplifier circuit, consisting of C1, R2, R1, C2, and U1, which converts the current into a voltage. This voltage is amplified by an op-amp (U3) according to the range setting selected by the digital gain set IC (U2). From here, the signal is switched synchronously with the flash lamp pulses. Finally, the voltage is converted to a frequency by U4 and sent to the microprocessor board.

Temperature Control Board

The Temperature Control Board sets and regulates the temperature of the fluorescence chamber. The fluorescence chamber temperature is measured by a thermistor mounted on a standoff of the Temperature Control Board. A comparator (IC1) turns Q1 on and off, which in turn drives the relay (K1). The relay switches ac line voltage on and off to the heaters mounted on the optical bench.

The Microprocessor System

The microprocessor system consists of printed circuit boards which plug into a motherboard, connecting them to each other and to the rest of the instrument. These boards are as follows:

- Display Module
- Processor Board
- Analog to Digital Board
- Digital to Analog Board
- C-Link Board

Display Module. The vacuum fluorescent display module shows SO_2 concentrations, instrument parameters, and help messages. The single board display module consists of 80 characters (4 line by 20 column), refresh memory, character generator, dc/dc converter and all necessary control logic. The display module is powered by +5 volts dc.

Processor Board. The Processor Board contains a Motorola M68HC11F1 microprocessor (U14), RAM (U5), and EEPROM (U2). In addition, this high-performance, nonmultiplexed 68-pin microprocessor, contains 512 bytes of EEPROM and 1K of RAM. It is operated at a frequency of 1 MHz, which is generated by crystal X1.

During each instruction cycle, the processor fetches an instruction from memory and executes it, reading or writing data to or from the data bus, or performing a calculation on some internal register or registers. The reset signal is generated by U7. This signal resets the M68HC11F1 every tenth of a second, and is used by the microprocessor to keep track of time. Each time the microprocessor is reset, it reads the counters, increments the clock, checks the status of the pushbuttons, and updates the D/A converters and display. The MC6840 counter chip (U1) acts as the interface between the Input Board and the microprocessor. A pulse train from the Input Board is directly fed into one of three counters on the MC6840 counter chip.

Digital/Analog Board. The Digital to Analog Board contains four 10 bit D/A converters, one for each analog output. Each is addressed by the processor via signals from PA0-PA7 and PG0 and PG1. The D/A converters are zeroed using potentiometers R2 and R4 and span is set using potentiometers R1 and R3. The fullscale output of the two D/A converters is set by jumpers on switches SW1 and SW2 on the D/A Board. Fullscale voltages of 10, 5, 1, and 0.1 volts are available.

Analog to Digital Board. The Analog to Digital Board acts as an interface between all the signals monitored by the processor system and the microprocessor itself. The internal ambient temperature, internal ambient pressure, and power supply voltages are converted to digital signals used by the microprocessor.

C-Link Board. The C-Link Board contains the RS-232 circuitry, clock, and memory for the datalogger. Incoming RS-232 signals are converted to TTL levels by U3, an RS-232 driver/receiver. The TTL signals are then interpreted by U5, a 68HC11 microprocessor, which is dedicated to remote communications. Data records from the internal datalogger are stored in U2, a 128K RAM, and the link program is stored in U6, a 64K EPROM. U10 is the internal clock. A battery supplies +5 volts to the clock and the data logger memory when instrument power off.

SUBASSEMBLIES

Hydrocarbon Kicker

The Hydrocarbon Kicker removes hydrocarbons from the gas stream while leaving the SO_2 concentration unaffected. It operates on a selective permeation principle, allowing only hydrocarbon molecules to pass through the tube wall. The driving force for the hydrocarbon removal is the differential partial pressure across the wall. This differential pressure is produced within the instrument by passing the sample gas through a capillary tube to reduce its pressure and feeding it into the shell side of the Hydrocarbon Kicker.

Optics

The optics section begins with a hermetically sealed lamp which is pulsed at a rate of 10 times per second. The lamp is operated in the pulsed mode for six major reasons.

- Long life
- High optical intensity - improved signal to noise ratio
- Small size
- Low power requirements - less than 1 watt
- Long term stability
- Chopped signal processing - no dark current drift

The light from this lamp is focused with a condensing lens into the mirror assembly. A set of eight mirrors selectively reflects only those wavelengths which are of use in exciting SO_2 molecules. This reflective filtering allows the radiation reaching the detection chamber to be both more intense and more stable throughout the lifetime of the instrument. After this reflective filtering, the light passes through a relay lens and into the fluorescence chamber. A circular baffle helps keep stray light from entering the actual detection volume.

The main detector assembly is located at a right angle to the incoming light. A condenser lens collects and focuses light from fluorescing SO_2 molecules. The light then passes through a bandpass filter which restricts the light reaching the photomultiplier tube to the SO_2 fluorescence wavelengths only.

Facing the light source, at the opposite side of the fluorescence chamber, is a light trap, which prevents light from reflecting back into the detection volume. At the center of this trap, a hole allows light to reach the photodetector located at the back of the fluorescence chamber. This photodetector continuously monitors the incident light. It is connected to a circuit which automatically compensates for fluctuations in the flash lamp output.

Flow Components

The sample is drawn into the Model 43C Trace Level through the **SAMPLE** bulkhead (see Figure 1-1). The sample flows through a hydrocarbon "kicker," which removes hydrocarbons from the sample by forcing the hydrocarbon molecules to permeate through the tube wall. The SO_2 molecules pass through the hydrocarbon "kicker" unaffected.

The sample then flows into the fluorescence chamber, where pulsating UV light excites the SO_2 molecules. The condensing lens focuses the pulsating UV light into the mirror assembly. The mirror assembly contains eight selective mirrors that only reflect the wavelengths which excite SO_2 molecules.

As the excited SO_2 molecules decay to lower energy states they emit UV light that is proportional to the SO_2 concentration. The bandpass filter allows only the wavelengths emitted by the excited SO_2 molecules to reach the photomultiplier (PMT). The PMT detects the UV light emission from the decaying SO_2 molecules. The photodetector, located at the back of the fluorescence chamber, continuously monitors the pulsating UV light source and is connected to a circuit that compensates for fluctuations in the UV light.

The sample then flows through a flow sensor, a capillary, and the shell side of the hydrocarbon "kicker." The Model 43C Trace Level outputs the SO_2 concentration to the front panel display and the analog outputs.

CHAPTER 9
OPTIONAL EQUIPMENT

This chapter describes optional equipment available for the Model 43C Trace Level.

RACK MOUNTS WITH SLIDES

Rack mounts with slides for standard 19-inch relay racks are available. Figures 9-1 and 9-2 illustrate the installation of the rack mount option. Also available, as Option 209, are the handle mounting brackets and handles without the rack mounts.

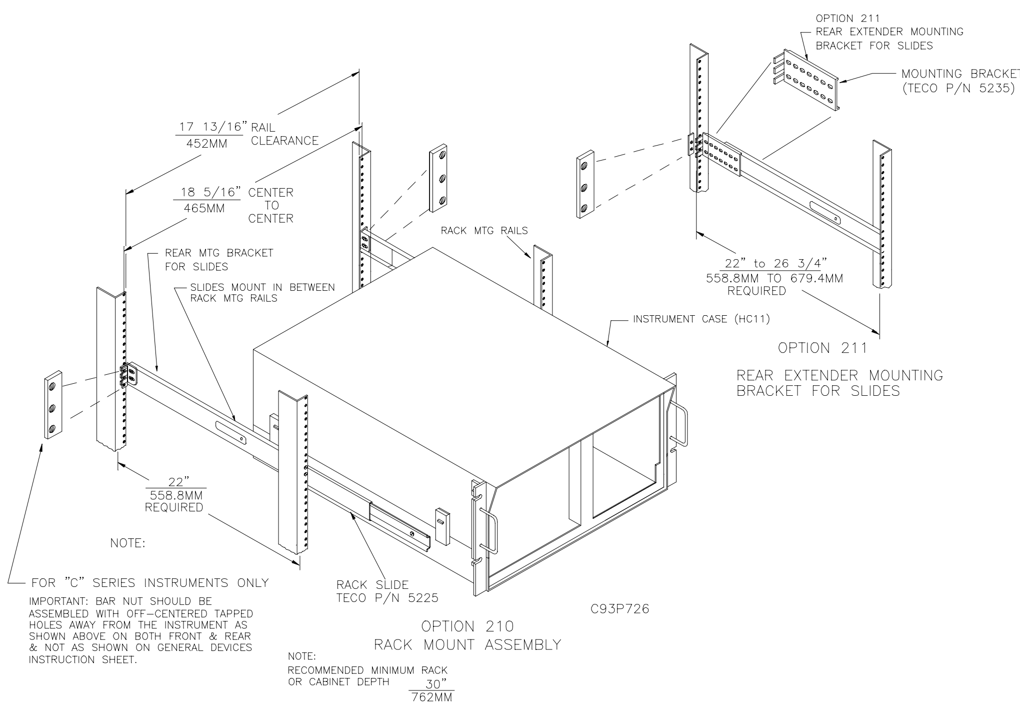


Figure 9-1. Rack Mount Option Assembly 93P726

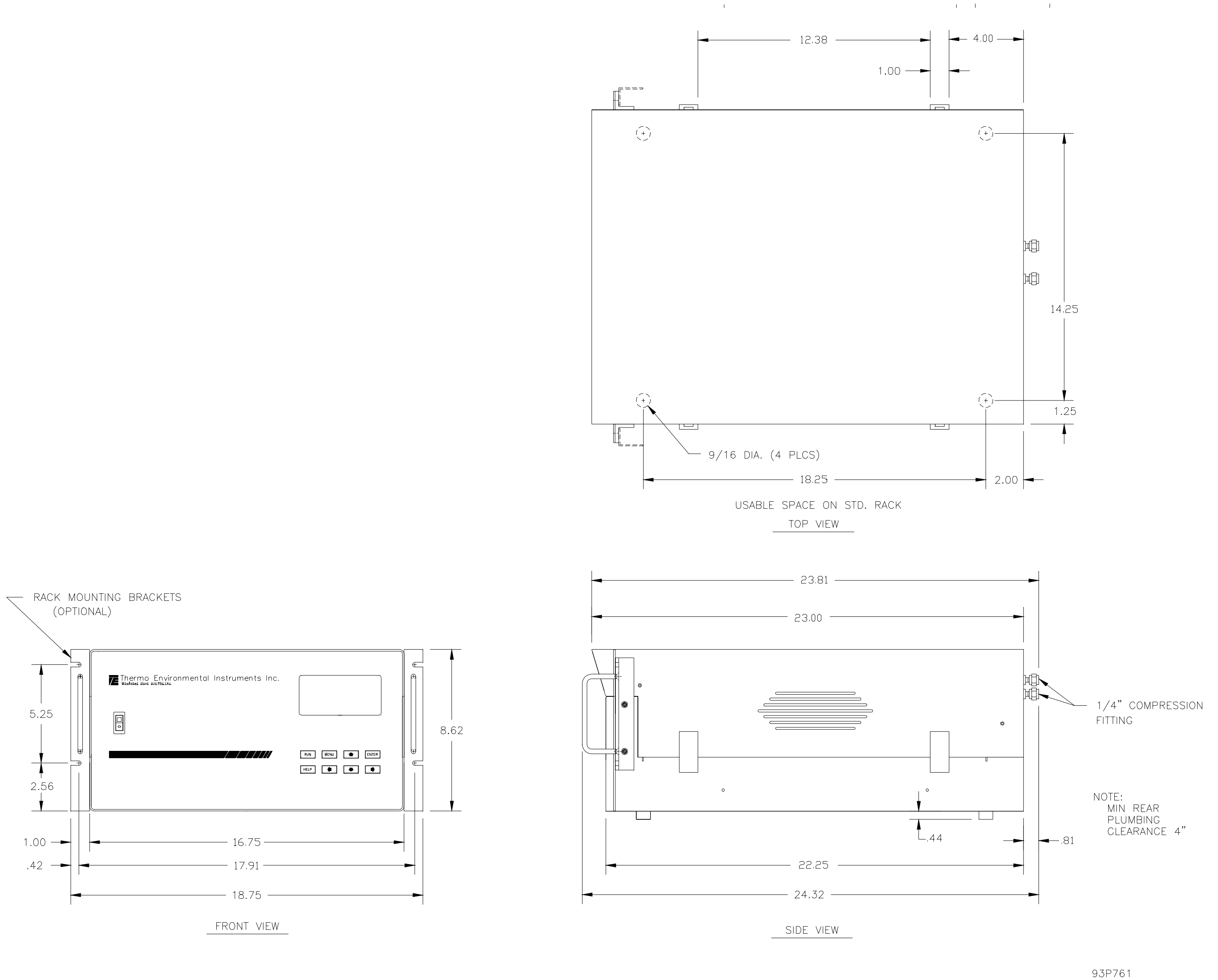


Figure 9-2. Model 43C Trace Level Dimensional Outline

INTERNAL ZERO/SPAN AND SAMPLE VALVES

With the zero/span and sample valve option, a source of span gas is connected to the **SPAN** port and a source of zero air is connected to the **ZERO** port (see Figure 2-1). Zero and span gas should be supplied at atmospheric pressure. It may be necessary to use an atmospheric dump bypass plumbing arrangement to accomplish this (see Figure 2-2). If this option is installed, option switch 3 must be on (see Figure 3-7).

Use the **RUN** pushbutton while in the Run screen to manually switch the valves between sample, zero, and span. The active mode is shown in the lower left corner of the display as shown below.

```
SO2 PPB          25.5
SAMPLE 10:25
```

Run Screen in Sample Mode

Zero/Span Check

Automatic zero/span checking is available in the local mode (option switch 1 off) with the zero/span valve option. Zero/Span Check appears in the Calibration screen as shown below. Use the 9 pushbutton to move the cursor to Zero/Span Check and press **ENTER**.

```
CALIBRATION:
>CALIBRATE ZERO
 CALIBRATE SO2
 ZERO/SPAN CHECK
```

Calibration Screen with Zero/Span Check

The Zero/Span Check menu appears as shown below.

```
ZERO/SPAN CHECK:
>NEXT DATE  01/15/96
 NEXT TIME     12:00
 PERIOD HRS       24

 Z DURATION MIN   15
 S DURATION MIN   15
```

Zero/Span Check Menu

To set zero/span check, follow the procedure below:

1. Set the date of the first zero/span check. The Next Date screen, shown below, is used to set the initial or start date of the zero/span check. Once the initial zero/span check is performed, the date of the next zero/span check is calculated and displayed.

```
START DATE 01/01/96
SET TO     01/02/96?

↑↓ INC/DEC ←→ CURSOR
```

Next Date Screen

2. Set the time of the first zero/span check. The Next Time screen, shown below, is used to set the initial time of the zero/span check. Once the initial zero/span check is performed, the time of the next zero/span check is calculated and displayed.

```
START TIME    12:00
SET TO        13:00?

↑↓ INC/DEC ←→ CURSOR
```

Next Time Screen

3. Set the period between zero/span checks. The Period screen, shown below, defines the period or interval between zero/span checks. Periods between 2 and 1,000 hours are acceptable. To turn the zero/span check off, set the period to 0.

```
PERIOD        24 HRS
SET TO        25 HRS?

↑↓ INC/DEC
```

Period Screen

4. Set the zero check and the span check duration. The Z (zero) Duration screen, shown below, defines how long zero air is sampled by the instrument. The S (span) Duration screen looks and functions the same way as the Z Duration screen, and is used to set how long the span gas is sampled by the instrument. Durations between 1 and 60 minutes are acceptable. Each time a zero/span check occurs, the zero check is done first, followed by the span check. To perform just a zero check, set the S Duration screen to 0. To perform just a span check, set the Z duration screen to 0.

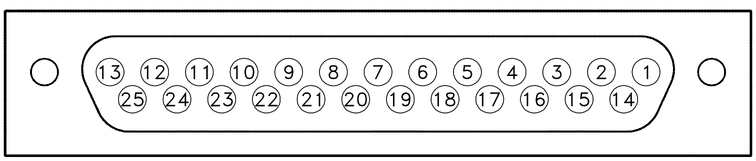
```
Z DURATION   30 MIN
SET TO       31 MIN?

↑↓ INC/DEC
```

Z Duration Screen

REMOTE ACTIVATION OF ZERO/SPAN AND SAMPLE VALVES

The rear panel I/O (DB25) connector, shown in Figure 9-3, enables the zero/span and sample valves to be remotely controlled via contact closure. In addition, the connector has several instrument status outputs. Option switch 1 must be on and option switch 2 off in order to enable the remote I/O connector.



Pin Out

(1) Ground
(2) NC
(3) NC
(4) NC
(5) INPUT - Zero Gas
(6) Ground
(7) Relay Common
(8) STATUS - Concentration Alarm
(9) STATUS - Local or Remote Mode
(10) STATUS - ppm or mg/m3 mode
(11) STATUS - General Alarm
(12) Relay Common
(13) NC
(14) Ground
(15) NC
(16) NC
(17) NC
(18) INPUT - Span Gas
(19) Ground
(20) Relay Common
(21) STATUS - Zero Gas Mode
(22) STATUS - Span Gas Mode
(23) NC
(24) STATUS - Sample Gas Mode
(25) Relay Common

64P947-5

Figure 9-3. Rear Panel I/O Connector

Input Pins

To activate the zero gas mode, connect pin 1, 6, 14, or 19 (ground) to pin 5 (zero gas mode), as shown in Figure 9-4. To deactivate the zero gas mode, disconnect ground from the zero gas mode input.

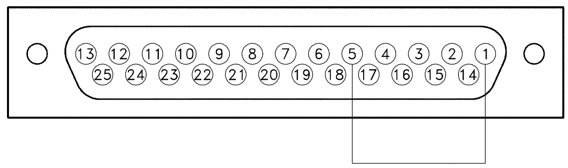


Figure 9-4. Remote I/O Zero Gas Mode Activation 64P947-6

To activate the span gas mode, connect pin 1, 6, 14, or 19 (ground) to pin 18 (span gas mode), as shown in Figure 9-5. To deactivate the span gas mode, disconnect ground from the span gas mode input.

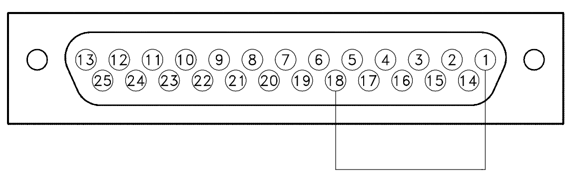


Figure 9-5. Remote I/O Span Gas Mode Activation 64P947-7

Instrument Status Outputs

Several instrument status outputs are available on the rear panel I/O connector via reed relays on the I/O Board. The reed relays are arranged as shown in Figure 9-6. In the instrument status output truth table, each pin is referred to as open or closed (based on the physical position of the corresponding relay). The Relay Common line is common to each of the relays.

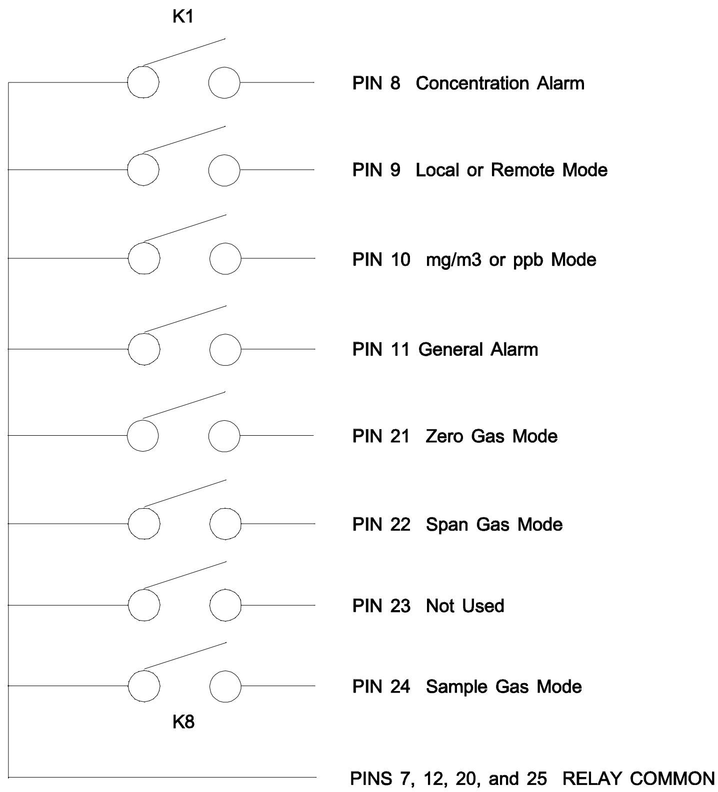


Figure 9-6. Instrument Status Output Relays

Status	Pin	Relay Closed	Relay Open
Concentration Alarm	8	Alarm	No Alarm
Local or Remote Mode	9	Local or Service Mode	Remote Mode
mg/m^3 or ppb Mode	10	mg/m^3 mode	ppb mode
General Alarm	11	Alarm	No Alarm

Status	Pin 21	Pin 22	Pin 24
Sample Gas Mode Active	Relay Open	Relay Open	Relay Closed
Zero Gas Mode Active	Relay closed	Relay Open	Relay Open
Span Gas Mode Active	Relay closed	Relay Closed	Relay Open

Table 9-1. Instrument Status Output Truth Table

4-20 mA ISOLATED CURRENT OUTPUT

A 4-20 mA Isolated Current Output enables the SO_2 concentration to be output at 4-20 mA as shown in Figure 9-7.

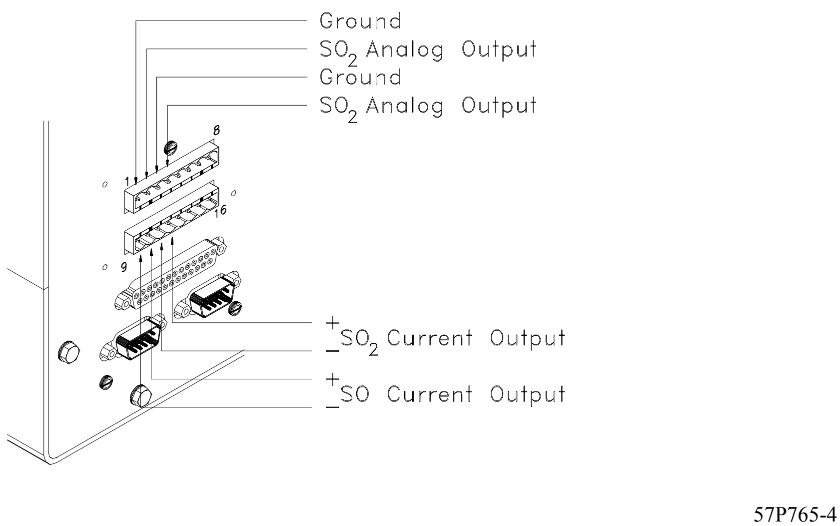


Figure 9-7. Pin-Out of Rear Panel Terminal Strip with Optional Current Output

INTERNAL PERMEATION SPAN SOURCE

The internal permeation span source is designed to provide a simple zero and span check. For more information about this option see Appendix C "Internal Permeation Span Source."

TEFLON® PARTICULATE FILTER

A 5-10 micron pore size, 2 inch diameter Teflon ® element is available for the Model 43C Trace Level. This filter should be installed just prior to the **SAMPLE** bulkhead. When using a filter, all calibrations and span checks must be performed through the filter.

INSTRUMENT HANDLE

An instrument handle is available to aid in carrying the instrument. It also enables the instrument to be slightly elevated, while resting on a table or bench, to increase visibility of the display. Figure 9-8 shows the installation of the instrument handle.

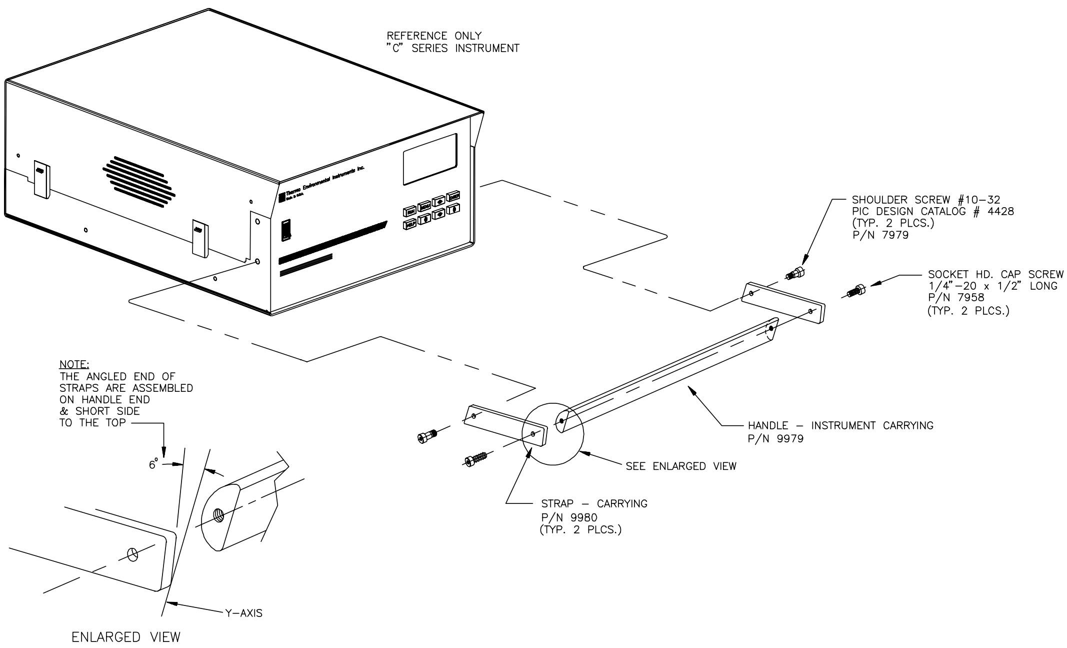


Figure 9-8. Instrument Handle Assembly 93P727

APPENDIX A
WARRANTY

Seller warrants that the Products will operate substantially in conformance with Seller's published specifications, when subjected to normal, proper and intended usage by properly trained personnel, for 13 months from date of shipment or 12 months from date of installation, whichever is less (the "Warranty Period"). Seller agrees during the Warranty Period, provided it is promptly notified in writing upon the discovery of any defect and further provided that all costs of returning the defective Products to Seller are pre-paid by Buyer, to repair or replace, at Seller's option, defective Products so as to cause the same to operate in substantial conformance with said specifications. Replacement parts may be new or refurbished, at the election of Seller. All replaced parts shall become the property of Seller. Shipment to Buyer of repaired or replacement Products shall be made in accordance with the provisions of Section 5 above. Lamps, fuses, bulbs and other expendable items are expressly excluded from the warranty under this Section 8. Seller's sole liability with respect to equipment, materials, parts or software furnished to Seller by third party suppliers shall be limited to the assignment by Seller to Buyer of any such third party supplier's warranty, to the extent the same is assignable. In no event shall Seller have any obligation to make repairs, replacements or corrections required, in whole or in part, as the result of (i) normal wear and tear, (ii) accident, disaster or event of force majeure, (iii) misuse, fault or negligence of or by Buyer, (iv) use of the Products in a manner for which they were not designed, (v) causes external to the Products such as, but not limited to, power failure or electrical power surges, (vi) improper storage of the Products or (vii) use of the Products in combination with equipment or software not supplied by Seller. If Seller determines that Products for which Buyer has requested warranty services are not covered by the warranty hereunder, Buyer shall pay or reimburse Seller for all costs of investigating and responding to such request at Seller's then prevailing time and materials rates. If Seller provides repair services or replacement parts that are not covered by the warranty provided in this Section 8, Buyer shall pay Seller therefore at Seller's then prevailing time and materials rates. ANY INSTALLATION, MAINTENANCE, REPAIR, SERVICE, RELOCATION OR ALTERATION TO OR OF, OR OTHER TAMPERING WITH, THE PRODUCTS PERFORMED BY ANY PERSON OR ENTITY OTHER THAN SELLER WITHOUT SELLER'S PRIOR WRITTEN APPROVAL, OR ANY USE OF REPLACEMENT PARTS NOT SUPPLIED BY SELLER, SHALL IMMEDIATELY VOID AND CANCEL ALL WARRANTIES WITH RESPECT TO THE AFFECTED PRODUCTS.

THE OBLIGATIONS CREATED BY THIS SECTION TO REPAIR OR REPLACE A DEFECTIVE PRODUCT SHALL BE THE SOLE REMEDY OF BUYER IN THE EVENT OF A DEFECTIVE PRODUCT. EXCEPT AS EXPRESSLY PROVIDED IN THIS SECTION 8, SELLER DISCLAIMS ALL WARRANTIES, WHETHER EXPRESS OR IMPLIED, ORAL OR WRITTEN, WITH RESPECT TO THE PRODUCTS, INCLUDING WITHOUT LIMITATION ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. SELLER DOES NOT WARRANT THAT THE PRODUCTS ARE ERROR-FREE OR WILL ACCOMPLISH ANY PARTICULAR RESULT.

APPENDIX B
RS-232/485 COMMANDS

The RS-232/485 interface enables the analyzer to be remotely controlled by a host remote device such as, a PC, PLC, datalogger, etc.

CONNECTIONS

On the rear panel of the analyzer there are two male DB9 connectors. Both connectors are identical, so either can be connected to the remote device. The remaining connector can be used to connect a second analyzer. Using a daisy-chain configuration, several analyzers can be connected to one remote device.

A null modem (crossed) cable is required when connecting the analyzer to an IBM Compatible PC. However, a straight cable (one to one) may be required when connecting the analyzer to other remote devices. As a general rule, when the connector of the remote device is female, a straight cable is required and when the connector is male, a null modem cable is required.

DATA FORMAT

1200, 2400, 4800, or 9600 baud
8 data bits
1 stop bit
no parity
All responses are terminated with a carriage return (hex 0D)

INSTRUMENT IDENTIFICATION NUMBER

Each command sent to the analyzer must begin with the instrument's identification number plus 128. For example, if the instrument ID is set to 25, then decimal 153 precedes each command. The analyzer ignores any command that does not begin with its instrument identification number.

COMMANDS

The analyzer must be in the remote mode in order to change instrument parameters via remote. However, the command "set mode remote" can be sent to the analyzer to put it in the remote mode. Report commands can be issued either in the remote or local mode.

The commands can be sent in either uppercase or lowercase characters. In the examples below, only the characters between the quotation marks ("") are sent and received. If an incorrect command is sent, a "bad cmd" message will be received. The example below sends the incorrect command "set time avg" instead of the correct command "set avg time".

Send: "set time avg"
Receive: "set time avg bad cmd"

---

so2

This command reports the current SO_2 concentration reading. The example below reports that the current SO_2 reading is 40 ppb.

Send: "so2"
Receive: "so2 0040E+0 ppb"

---

gas mode

This reports the current mode of sample, zero, or span. The example below reports that the gas mode is sample.

Send: "gas mode"
Receive: "gas mode sample"

---

set sample gas

This command sets the optional valves to the sample mode. The example below sets the instrument to sample mode, that is, the instrument is reading the sample gas.

Send: "set sample gas"
Receive: "set sample gas ok"

---

set zero gas

This command sets the optional valves to the zero mode. The example sets the instrument in the zero mode, that is, the instrument is sampling zero air.

Send: "set zero"
Receive: "set zero ok"

set span gas

This command sets the optional valves to the span mode. The example below sets the instrument to the span mode, that is, the instrument is sampling span gas.

Send: "set span"
Receive: "set span ok"

mode

This reports what operating mode the instrument is in: local or remote. The example below shows that the instrument is in the remote mode.

Send: "mode"
Receive: "mode remote"

set mode local
set mode remote

These commands set the instrument to local or remote mode. The example below sets the instrument to the local mode.

Send: "set mode local"
Receive: "set mode local ok"

---

gas unit

This reports the current gas units (ppb or $\mu g/m^3$). The example reports that the gas unit is set to ppb.

Send: "gas unit"
Receive: "gas unit ppb"

---

set gas unit *unit*

unit = | ppb | ug/m3 |

This command sets the gas units to ppb or $\mu g/m^3$. The example below sets the gas units $\mu g/m^3$.

Send: "set gas unit ug/m3"
Receive: "set gas unit ug/m3 ok"

---

range so2

This command reports the current SO_2 range. The example below reports that the SO_2 range is set to 50 ppb.

Send: "range so2"
Receive: "range so2 2: 5000E-2 ppb"

---

set range *d*

d = Code in table below

This command selects the SO_2 fullscale range according to the tables below. The example below sets the SO_2 fullscale range to 50 ppb.

Send: "set range 7"
Receive: "set range 7 ok"

Standard Ranges:

Code	ppb	μg/m^3
0	10	20
1	20	50
2	50	100
3	100	200
4	200	500
5	500	1000
6	1,000	2000
8	C1	C1
9	C2	C2
10	C3	C3

---

custom *d*

d = | 1 | 2 | 3 |

This reports the user-defined value of custom range 1, 2, or 3. The example below reports that custom range 1 is defined to 55.0 ppb.

Send: "custom 1"
Receive: "custom 1 5500E-2 ppb"

---

set custom 1 range *ddddd.d*
set custom 2 range *ddddd.d*
set custom 3 range *ddddd.d*

These commands are used to define the custom ranges. To use the custom range select it using the set range command. The example below defines custom range 1 to 55.5 ppb.

Send: "set custom 1 range 55.5"
Receive: "set custom 1 range 55.5 ok"

---

avg time

This reports the averaging time setting. The example below reports that the averaging time is set to 60 seconds.

Send: "avg time"
Receive: "avg time 060 sec"

set avg time *d*

d = Code in table below

Sets the averaging time according to the Table below. The example below sets the averaging time to 60 seconds.

Send: "set avg time 3"
Receive: "set avg time 3 ok"

Code	Averaging time (seconds)
0	1
1	2
2	5
3	10
4	20
5	30
6	60
7	90
8	120
9	180
10	240
11	300

so2 bkg

This command reports the current SO_2 background. The example below reports that the SO_2 background is 2.7 ppb.

Send: "so2 bkg"
Receive: "so2 bkg 002.7 ppb"

set so2 bkg *dd.d*

This command is used to set the SO_2 background to a user-defined value. The example below sets the SO_2 background to 2.7 ppb.

Send: "set so2 bkg 2 2.7"
Receive: "set so2 bkg 02.7 ok"

coef so2

This command reports the current SO_2 coefficient. The example below reports that the SO_2 coefficient is 1.005.

Send: "so2 coef"
Receive: "so2 coef 1.005"

set coef so2 *d.ddd*

This command sets the SO_2 coefficient to a user-defined value. The example below sets the SO_2 coefficient to 1.005.

Send: "set so2 coef 1.005"
Receive: "set so2 coef 1.005 ok"

lamp status

This reports the status of the flash lamp: on or off. The example below reports that the flash lamp is on.

Send: "lamp status"
Receive: "lamp status on"

set lamp on
set lamp off

These commands turn the flash lamp on and off. The example below turns the flash lamp on.

Send: "set lamp on"
Receive: "set lamp on ok"

temp comp

This reports whether temperature compensation is on or off. The example below shows a typical response to this command.

Send: "temp comp"
Receive: "temp comp off"

set temp comp on
set temp comp off

This command turns the temperature compensation on and off. The example below turns temperature compensation off.

Send: "set temp comp off"
Receive: "set temp comp off ok"

pres comp

This reports whether pressure compensation is on or off. The example below shows that pressure compensation is on.

Send: "pres comp"
Receive: "pres comp on"

set pres comp on
set pres comp off

These commands turn the pressure compensation on and off. The example below turns pressure compensation off.

Send: "set pres comp off"
Receive: "set pres comp off ok"

time

This reports the current time (military time). The example below reports that the internal time is 2:15:30 pm.

Send: "time"
Receive: "time 14:15:30"

set time *hh:mm:ss*

hh = hours
mm = minutes
ss = seconds

Sets the internal clock (military time). The example below sets the internal time to 2:15 pm. Note that if seconds are omitted, the seconds default to 00.

Send: "set time 14:15"
Receive: "set time 14:15 ok"

date

This reports the current date. The example below reports the date as December 1, 1996.

Send: "date"
Receive: "date 12-01-96"

set date *mm-dd-yy*

mm = month
dd = day
yy = year

Sets the internal date. The example below sets the internal date to December 1, 1996.

Send: "set date 12-01-96"
Receive: "set date 12-01-96 ok"

pmt voltage

This reports the current PMT voltage. The example below reports that the current PMT voltage is -510 volts.

Send: "pmt voltage"
Receive: "pmt voltage -0510 volts"

internal temp

This reports the current internal instrument temperature. The first temperature reading is the temperature being used in instrument calculations. The second temperature is the actual temperature being measured. If temperature compensation is on, then both temperature readings are the same. If temperature compensation is off, a temperature of 30°C is used as the default temperature even though the actual internal temperature is 27.2°C. The example below shows that temperature compensation is on and that the internal temperature is 27.2°C.

Send: "internal temp"
Receive: "internal temp 027.2 deg C, actual 027.2"

react temp

This reports the current reaction chamber temperature. The example below reports that the current reaction chamber temperature is 45.2°C.

Send: "react temp"
Receive: "react temp 045.2 deg C"

lamp int

This reports the current flash lamp intensity. The example reports that the current flash lamp intensity is 35,867 Hz.

Send: "lamp int"
Receive: "lamp int 35867 Hz"

lamp voltage

This command reports the current flash lamp voltage. The example below reports that the flash lamp voltage is 810 volts.

Send: "lamp voltage"
Receive: "lamp voltage 810 V"

led status

This command reports the status of the optical test LED (on or off). The example below reports that the optical test LED is off.

Send: "test led status"
Receive: "test led status off"

---

set led on
set led off

These commands turn the optical span test led on and off. The example below turns the optical test led off.

Send: "set test led off"
Receive: "set test led off ok"

---

pres

This reports the current reaction chamber pressure. The first pressure reading is the pressure reading being used in instrument calculations. The second pressure is the actual pressure reading being measured. If pressure compensation is on, then both pressure readings are the same. If pressure compensation is off, a pressure of 760 mm Hg is used as the default pressure even though the actual pressure is 753.4 mm Hg. The example below shows that actual reaction chamber pressure is 753.4 mm Hg.

Send: "pres"
Receive: "pres 760.0 mm Hg, actual 753.4"

---

flow

This reports the current sample flow. The example below reports that the current sample flow is 0.503 liters/minute.

Send: "flow"
Receive: "flow 0.503 l/m"

---

dtoa *d*

d = DTOA in table below

This reports the outputs of the 7 Digital to Analog converters (0000 = 0.0% FS, 1000 = 100.0% fullscale). The example below shows that the D/A for the SO_2 voltage Out is 97.7% fullscale.

Send: "dtoa 1"
Receive: "dtoa 1 0977"

DTOA	Function
1	SO_2 Voltage Output
2	SO_2 Voltage Output
3	Not Used
4	Not Used
5	SO_2 Current Output
6	SO_2 Current Output
7	Not Used

perm gas temp

This reports the current permeation gas temperature. The example below reports that the permeation gas temperature is 45.0°C.

Send: "perm gas temp"
Receive: "perm gas temp 045.0 deg C"

option switches

This reports the status (on/off) of the 8 option switches. For example, a return of 11100000, means that option switches 1, 2, and 3 are on and the others are off (see "Internal Option Switches" in Chapter 3 "Operation," for more information about option switches). The example below shows that option switches 1, 2, and 3 are on.

Send: "option switches"
Receive: "option switches 11100000"

program no

This reports the analyzer's program number and the Link (communications) program number. The example below shows that the installed processor program is 43TR0001 00 and the installed communication program (link) is 43LTR000100.

Send: "program no"
Receive: "program no processor 43TR0001 00 link 43LTR0001 00"

set save params

This command stores parameters in the EEPROM. It is important that each time instrument parameters are changed, that this command be sent. If changes are not saved, they will be lost in the event of a power failure. The example below saves the parameters to EEPROM.

```
Send:       "set save params"
Receive:    "set save params ok"
```

screen

This reports the information currently being displayed on the instrument's front panel display. The example below shows a typical response to this command.

```
Send:       "screen"
Receive:    "                          "
            "SO2   PPB          29.5"
            "                          "
            "SAMPLE   14:25     REMOTE"
```

push *button*

button = | run | menu | enter | help | up | down | left | right |

This command is used to simulate pressing the Model 43C Trace Level front panel pushbuttons. In the example below, the push command is used in conjunction with the screen command to view the Main Menu. Note that the instrument is in the Run screen initially.

```
Send:       "push menu"
Receive:    "push menu ok"

Send:       "screen"
Receive:    "MAIN MENU:            10:25"
            ">RANGE                     "
            "  AVERAGING TIME           "
            "  CALIBRATION FACTORS      "
```

format

This command reports the current reply termination format as shown below:

Send: "format"
Receive: "format 00"

Code	Reply Termination
00	<CR>
01	0x80 xxxx <CR>

where xxxx = the sum of all characters in the message

set format *dd*

dd = | 00 | 01 |

This command sets the reply termination format. The example below sets the reply termination format to checksum.

Send: "format 01"
Receive: "format 01 ok"
"sum 0570"

Code	Reply Termination
00	<CR>
01	<nl>sum xxxx<CR>

where xxxx = 4 hexadecimal digits that represent the sum of all the characters in the message

set lrec format *tt ff*
set srec format *tt xx*

tt = | 00 | 01 | 02 | 03 | 04 |
ff = | 00 | 01 | 02 | 03 |
xx = | 00 | 01|

There are two types of records that the internal data logger stores: long records and short records. Both records contain the time, date, SO_2 average, and the instrument status flags. The SO_2 average is taken over the logging interval. For example, if the long record (or lrec) logging time is set to 30 minutes, then the SO_2 reading is the average SO_2 reading during the last 30 minutes. In addition, the long record contains the following data: PMT voltage, lamp voltage, lamp intensity, internal instrument temperature, reaction chamber temperature, pressure, and sample flow readings. These readings are instantaneous measurements. The data logger can store 1,792 long records and 4,096 short records.

The logging time for each record is defined as follows:

Time	Logging Time (minutes)
00	1
01	5
02	15
03	30
04	60

The records may be output several ways:

Reply	Output Format
00	Short reply (no temps, flows, etc.) with no text
01	Short reply (no temps, flows, etc.) with text
02	Long reply (temps, flows, etc.) with no text
03	Long reply (temps, flows, etc.) with text

The example below sets the lrec logging time to 5 minutes and the output format to long reply with text.

Send: "set lrec format 01 03"
Receive: "set lrec format 01 03 ok"

---

lrec *xxxx yy*
srec *xxxx yy*

xxxx = number of records back
yy = the number of records to return (0 to 10)

These commands output the contents of the data logger's records. The output format and logging time are determined by the set lrec format and set srec format commands as described above. In the example below, the instrument reports the contents of 5 long records, starting with the 100th previous record. The logging time is set to 5 minutes and the text is being displayed.

Send: "lrec 100 5"
Receive:

"10:15 12-28 so2 2560E+0 ppb flags 40000000 pmtv -0510 lmpv 0810 lmpi 35867 intt 30.1 rctt 45.2 pgst 0.00 flow 0.503 pres 753.4
10:20 12-28 so2 2580E+0 ppb flags 40000000 pmtv -0510 lmpv 0810 lmpi 35870 intt 30.1 rctt 45.2 pgst 0.00 flow 0.503 pres 753.4
10:25 12-28 so2 2570E+0 ppb flags 40000000 pmtv -0510 lmpv 0810 lmpi 35868 intt 30.1 rctt 45.2 pgst 0.00 flow 0.503 pres 753.4
10:30 12-28 so2 2560E+0 ppb flags 40000000 pmtv -0510 lmpv 0810 lmpi 35867 intt 30.1 rctt 45.2 pgst 0.00 flow 0.503 pres 753.4
10:35 12-28 so2 2570E+0 ppb flags 40000000 pmtv -0510 lmpv 0810 lmpi 35866 intt 30.1 rctt 45.2 pgst 0.00 flow 0.503 pres 753.4"

where:

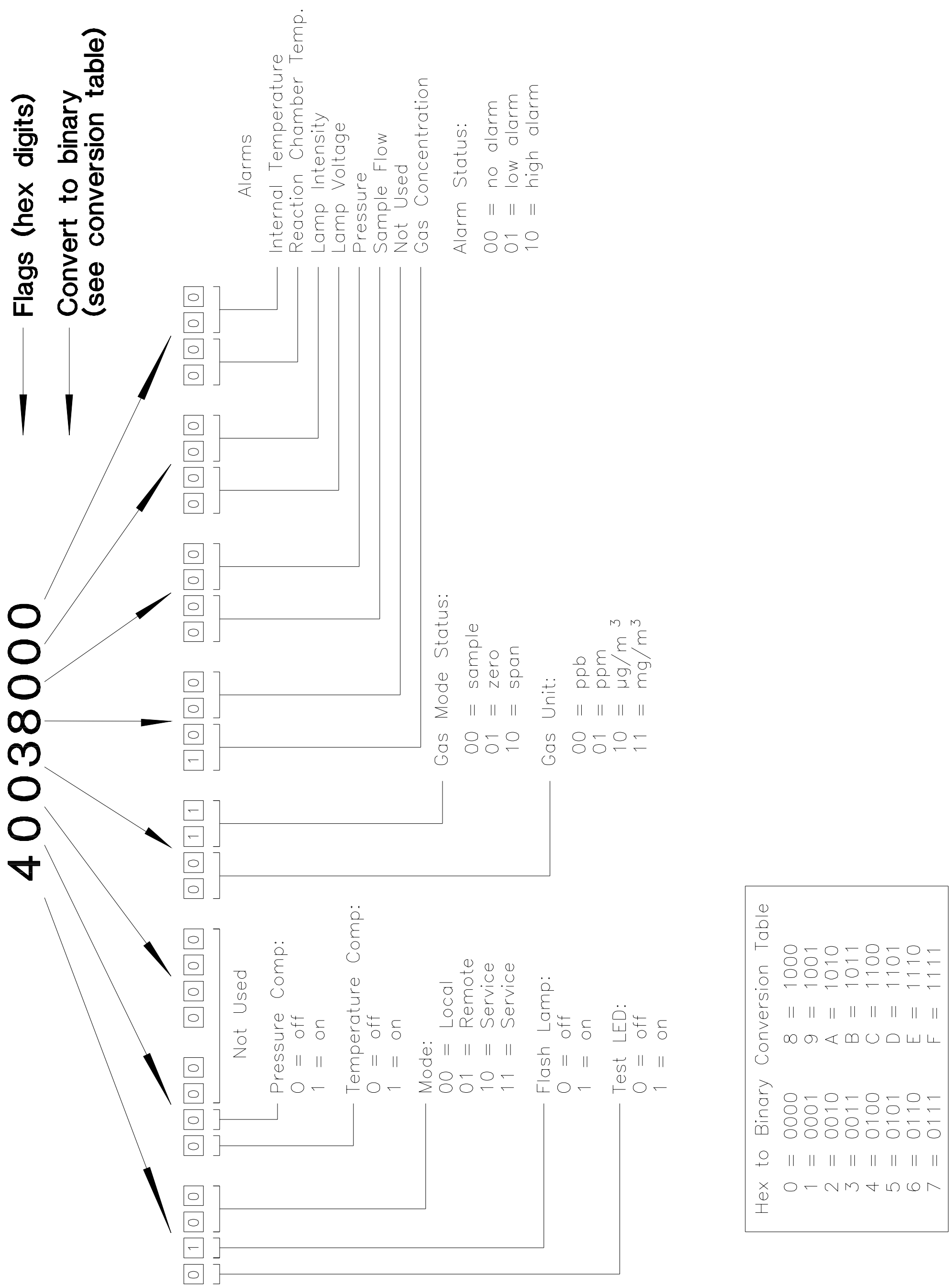
pmtv = PMT Voltage
lmpv = Lamp Voltage
lmpi = Lamp Intensity
intt = Internal Temperature
rctt = Reaction Chamber Temperature
pgst = Permeation Gas Temp (0.00 is shown when permeation oven is not installed)
flow = Sample Flow
pres = Pressure

---

flags

This reports 8 hexadecimal digits (or flags) that represent the status of the ozonator, PMT, gas mode, and alarms. To decode the flags, each hexadecimal digit is converted to binary as shown in the figure below. It is the binary digits that define the status of each parameter. In the example below, the instrument is reporting that the flash lamp is on, that the instrument is in the span gas mode, and that the SO_2 high concentration alarm is activated.

Send: "flags"
Receive: "flags 40028000"


Flags (hex digits)
Convert to binary (see conversion table)
40038000
0100 0000 0000 0000 0011 1000 0000 0000 0000 0000 0000
Not Used
Pressure Comp:
0 = off
1 = on
Temperature Comp:
0 = off
1 = on
Mode:
00 = Local
01 = Remote
10 = Service
11 = Service
Flash Lamp:
0 = off
1 = on
Test LED:
0 = off
1 = on
Gas Mode Status:
00 = sample
01 = zero
10 = span
Gas Unit:
00 = ppb
01 = ppm
10 = µg/m 3
11 = mg/m 3
Alarms
Internal Temperature
Reaction Chamber Temp.
Lamp Intensity
Lamp Voltage
Pressure
Sample Flow
Not Used
Gas Concentration
Alarm Status:
00 = no alarm
01 = low alarm
10 = high alarm
Hex to Binary Conversion Table
0 = 0000 8 = 1000
1 = 0001 9 = 1001
2 = 0010 A = 1010
3 = 0011 B = 1011
4 = 0100 C = 1100
5 = 0101 D = 1101
6 = 0110 E = 1110
7 = 0111 F = 1111

APPENDIX C
INTERNAL PERMEATION SPAN SOURCE

The Internal Permeation Span Source option is designed to provide a simple zero and span check. Because this option does not precisely control dilution gas flow, this option should not be used as a basis for analyzer zero and span adjustments, calibration updates or adjustment of ambient data. This option is intended as a quick, convenient check to be used between zero and span calibrations for determining analyzer malfunction or drift. Whenever there is an indication of possible analyzer drift or malfunction, a full zero and multipoint calibration (Level 1) should be performed prior to corrective action. For further information on zero, span and calibration of air pollution monitors, refer to Section 2.0.9 of the US EPA's Quality Assurance Handbook for Air Pollution Measurement Systems (Volume II).

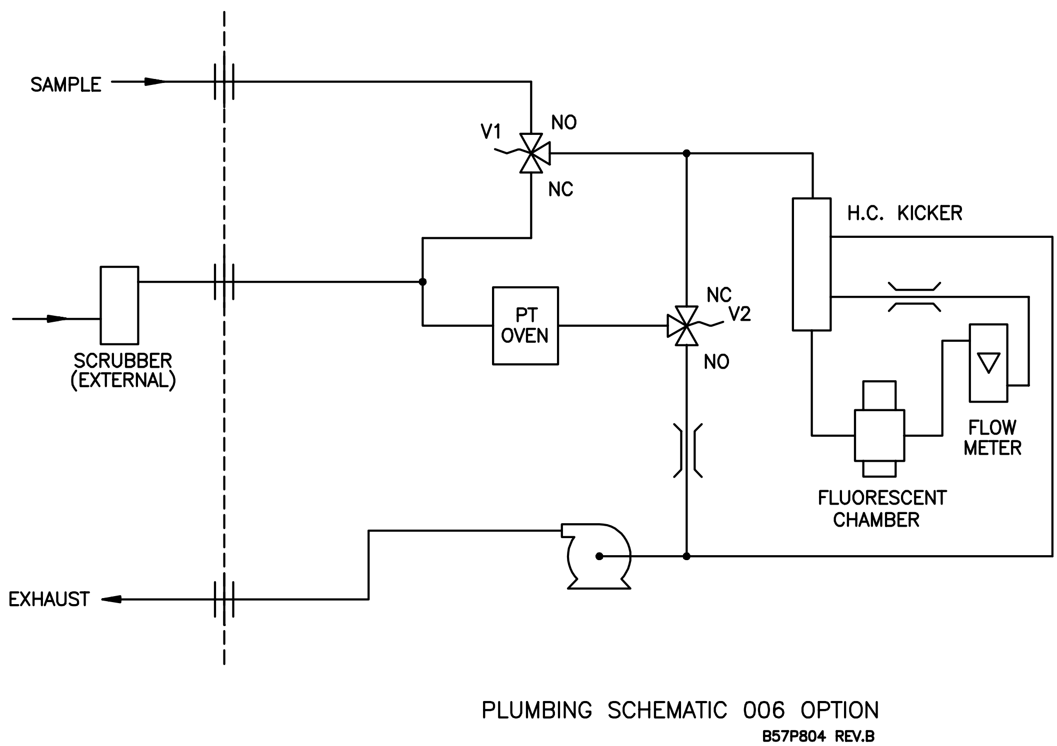


Figure C-1. Internal Permeation Span Source Flow Schematic 57P904

The method of operation of the Model 43C Trace Level with this option can be seen by referring to Figure C-1. Energizing the valve labeled V1 shuts off the sample flow and permits the flow of zero air for analysis. When valves V1 and V2 are energized, the flow of zero air is blended with air containing SO_2 from the permeation oven. This mode of operation provides the single span check feature of this option.

SPECIFICATIONS

Temperature control	Single Point 45°C
Temperature stability	±0.1°C
Warm-up time	1 hour (permeation device can take 24 to 48 hours to stabilize)
Carrier gas flow	70 scc/min
Chamber size	Accepts permeation tubes up to 9 cm in total length; 1 cm in diameter.
Temperature range	10 to 30°C
Physical dimensions	Contained inside the Model 43C Trace Level (except the charcoal scrubber).
Power requirements	50 watts, 50/60 Hz, 120/220 VAC (in addition to the standard Model 43C Trace Level).
Weight	Approximately 5 lbs. (in addition to the standard Model 43C Trace Level).
Remote operation	RS-232 Interface or Contact Closure

PERMEATION TUBE INSTALLATION

1. Remove the oven cover.
2. Remove the glass chamber assembly by loosening (not removing) the knurled screw and gently pulling the assembly upward. Completely remove from the oven.
3. Separate the glass chamber from the top assembly by twisting and gently pulling the glass away from the top.
4. Keep the glass clean when handling the glass.
5. Place permeation tube(s) in chamber.
6. Attach the glass chamber to the top assembly by gently pushing the two together with a slight twisting motion.
7. Replace the glass chamber assembly into the oven until top of the assembly is flush or slightly below the top of the oven.
8. Tighten the knurled screw finger-tight.
9. Do not use tools to tighten.
10. Replace the oven cover, be sure to place the tubing and wire into the slot of cover.

COMPUTATION OF CONCENTRATIONS

The computation of SO_2 output level is shown below. Note that it is assumed that all devices are properly calibrated and that all flows are corrected to 25°C and 1 atm.

Permeation Tube:

$$\text{Output (ppm)} = \frac{(R)(K)}{Q_o}$$

Where:

R = permeation rate in ng/min

K = constant for the specific permeant, 0.382

Q_o = flow rate of gas (ml/min) into the charcoal scrubber during span mode.

OVEN TEMPERATURE CORRECTION CALIBRATION (D/A 4

The Model 43C Trace Level uses the oven temperature correction signal (D/A 4) to maintain a constant temperature in the permeation oven. Follow the procedure below to calibrate D/A 4:

1. From the Service Mode menu select Permeation Oven.
2. From the Permeation Oven menu select Cal DTOA #4. Press **ENTER** to set D/A 4 to 0 volts. The screen below appears.

```
DTOA #4           0
SET TO        1000?
adj  z4 for  0.000 V
between pins 7 and 8
```

Cal DTOA #4 Screen

3. Adjust Z4 on the Digital/Analog Board until 0.000 volts is measured across pins 7 and 8 on the rear panel analog output connector.
4. Press **ENTER** to set D/A 4 to 10 volts. Adjust SP4 on the Digital/Analog Board until 10.000 volts is measured across pins 7 and 8.
5. Press **MENU** to return to the Permeation Oven menu.

PERMEATION TUBE OVEN CALIBRATION

There are two general approaches that can be used to calibrate the permeation tube oven. The first is to calibrate the temperature indicator very accurately (to better than 0.02°C), and to use a permeation tube whose weight loss has been previously determined at that temperature (note, an error of about 0.1°C corresponds to an error of 1% in release rate). The second approach is to note that the thermistors used to measure temperature are interchangeable to better than ± 0.2°C. Thus a 1% resistor of the proper value (4.369 K ohm for 45°C) can be used to set the span on the Oven Controller Board. The release rate for the permeation tube is then determined by weight loss in the actual oven being used.

Setting Measure Temperature with Water Bath

1. Unplug J3 from the Oven Controller Board. Place a 4.369 KΩ resistor across pins 3 and 4 of J3 on the Oven Controller Board.
2. From the Permeation Oven menu, select Cal Oven Thermistor. Adjust R2 on the Oven Controller Board until the oven drive voltage is 5.000 volts. Press **MENU** to return to the Permeation Oven menu.

```
OVEN DRIVE   4.848 V
replace gas therm
with 4369 ohms,
adj R2 for 5.000 V
```

Cal Oven Thermistor Screen

3. Remove the thermistor from the permeation tube oven. Leave the thermistor connected to the Oven Controller Board. Insert the thermistor into the water bath next to a NIST traceable thermometer. (If necessary, use an extension cable to reach).
4. Turn on the power to the water bath. Using an NIST traceable thermometer with a resolution of ± 0.01°C, adjust water bath to 45°C.
5. From the Permeation Oven menu, select Cal Gas Thermistor. Adjust R4 on the Oven Controller Board until the permeation gas temperature reading is 45°C.

```
PERM GAS    45.00 °C
replace gas therm
with 4369 ohms,
adj R4 for 45.00 °C
```

Cal Gas Thermistor Screen

6. Remove thermistor from the water bath, dry, and replace into the permeation tube oven.
7. Make sure the charcoal scrubber is connected to the **ZERO** bulkhead on the rear panel.
8. Wait for the permeation gas temperature reading to stabilize.

9. From the Permeation Oven menu, select Set Gas Temperature. Adjust R2 until the Perm Gas reading displayed on the first line is 45.00°C. Since it takes several minutes for the permeation oven temperature to stabilize, it is best to wait 10 minutes between adjustments.

```
PERM GAS     45.00 °C
OVEN DRIVE    4.848 V
adJ R2, wait 10 min,
repeat until 45.0 °C
```

Set Gas Temperature Screen

Setting Measure Temperature with an Accurately Known Oven Temperature

1. Unplug J3 from the Oven Controller Board. Place a 4.369 KΩ resistor across pins 3 and 4 of J3 on the Oven Controller Board.
2. From the Permeation Oven menu, select Cal Oven Thermistor. Adjust R2 on the Oven Controller Board until the oven drive voltage is 5.000 volts. Press **MENU** to return to the Permeation Oven menu.

```
OVEN DRIVE    4.848 V
replace gas therm
with 4369 ohms,
adJ R2 for 5.000 V
```

Cal Oven Thermistor Screen

1. Remove thermistor from J1 on the Oven Controller Board.
2. Connect a resistance of 4.369 KΩ across pins 1 and 2 of J1 (use a resistance substitution box and an accurate meter if necessary).

3. From the Permeation Oven menu, select Cal Gas Thermistor. Adjust R4 on the Oven Controller Board until the permeation gas temperature reading is 45°C.

```
PERM GAS      45.00 °C
replace gas  therm
with 4369 ohms,
adj R4  for 45.00 °C
```

Cal Gas Thermistor Screen

4. Reconnect measure thermistor.
5. Make sure the charcoal scrubber is connected to the **ZERO** bulkhead on the rear panel.
6. Wait for the permeation gas temperature reading to stabilize.
7. From the Permeation Oven menu, select Set Gas Temperature. Adjust R2 until the Perm Gas reading displayed on the first line is 45.00°C. Since it takes several minutes for the permeation oven temperature to stabilize, it is best to wait 10 minutes between adjustments.

```
PERM GAS      45.00 °C
OVEN DRIVE     4.848 V
adj R2, wait 10 min,
repeat until  45.0 °C
```

Set Gas Temperature Screen

DETERMINATION OF PERMEATION RATE BY WEIGHT LOSS

1. Make sure the oven has been calibrated as described above.
2. Insert the permeation tube carefully. Do not touch with fingers.
3. Turn on the Model 43C Trace Level.
4. Wait 48 to 72 hours for the permeation tube to stabilize.
5. Carefully remove the permeation tube from the oven and weigh to an accuracy of 0.1 mg. Perform this measurement as quickly as possible.
6. Replace permeation tube into the oven of the Model 43C Trace Level.
7. Repeat steps 5 and 6 after two weeks.
8. Compute the weight loss of the permeation tube from the values determined in steps 5, 6, and 7 above.
9. Repeat steps 5 to 8 until the weight loss has been determined to a precision of 1 to 2%.
10. For most accurate work, use the permeation tube in the same oven that was used to determine the permeation tube's weight loss.

DETERMINATION OF RELEASE RATE BY USE OF TRANSFER STANDARD

1. Make sure the permeation oven temperature in the Model 43C Trace Level has been calibrated. Also make sure that the Transfer Standard has been properly calibrated.
2. Determine the permeation rate for the permeation tube in the transfer standard, or install a certified permeation tube.
3. Allow the permeation tubes in both instruments, Model 43C Trace Level and Transfer Standard, to stabilize at least 48 hours.
4. Carefully calibrate the Model 43C Trace Level using the Transfer Standard. The output of the transfer standard should be connected to the sample bulkhead on the rear panel of the Model 43C Trace Level.
5. Switch the calibrated Model 43C Trace Level into the span mode. Measure the flow rate into the **ZERO** bulkhead on the rear panel of the Model 43C Trace Level. Be sure that the charcoal scrubber is connected. Note the flow and the measured SO_2 concentration.
6. From the flow and measured concentration, compute the permeation tube release rate.

APPENDIX D
STANDARDS FOR TRACE LEVEL ANALYZERS

The development of ultra-sensitive analytical analyzers for the measurement of trace quantities of pollutants such as NO, NO_2, or SO_2, has raised a number of questions concerning proper calibration procedures and equipment. Analyzers that in theory have detection limits below 1 ppb, may not in practice be useful due to inadequate and/or inaccurate calibration practices.

Thermo Environmental Instruments Inc. (TEI) has in its development of Trace Level instrumentation used the same basic principles for calibration as for standard analyzers. However, enhanced emphasis on the zero air supply used for dilution of standard gases and for establishing a zero background signal is made.

Chemiluminescence NO/NO_x and fluorescence SO_2 analyzers (when properly designed) have been shown in numerous research studies and compliance monitoring situations to be inherently linear over a wide dynamic range. Calibration is normally done using first a zero gas then a span gas generated by dilution of a calibration gas cylinder. Dilution is done by dynamic mixing of accurately known flows of span gas and zero gas. For Trace level analyzers, mass flow controllers that are NIST traceable are required. Nitric oxide and sulfur dioxide calibration standards between 1 and 10 ppm are readily available in specially treated cylinders, and have been shown to have excellent stability and accuracy. NIST traceable mass flow controllers with full scale ranges from 20 sccm to 20,000 sccm are also readily available. It is therefore relatively straight forward to generate span gas concentrations from below 1 ppb to 10 ppb assuming a suitable zero gas source is used. For example:

$$[\mathrm{NO}]_{\mathrm{GENERATED}} = [\mathrm{NO}]_{\mathrm{SPAN}} \times \frac{\mathrm{NO\ Flow}}{\mathrm{Total\ Flow}}$$

Assuming a calibration cylinder of 1 ppm, NO flow of 10 sccm, and a total flow of 10,000 sccm, allows generation of a span concentration of 1 ppb. Using the specifications of the mass flow controllers and calibration cylinder, this concentration should be accurate to withiṇ 5%. Multi-point concentrations from 0.5 ppb to 10 ppb may be similarly generated, establishing the linearity of the particular analyzer being calibrated. TEI believes it is not necessary to generate concentrations below these levels since the fundamental linearity of the instrumentation has been demonstrated.

If however, the zero air used for dilution and for establishing baseline conditions has impurity levels greater than several tenths of a ppb, the accuracy of the analyzer being calibrated may be severely jeopardized. A 0.5 ppb impurity level is equivalent to a 10% relative error for a 5 ppb concentration.

Ultra-zero ambient monitoring gases are available from gas suppliers, however, the typical analyses for NO_x and SO_2 impurities only guarantee levels below 5 ppb. In practice, TEI personnel as well as other users of Trace Level equipment have found these gases to be at least an order of magnitude better than what is guaranteed, and therefore are adequate for most purposes. Non-reactive and diffusion resistant regulators are required, and as the cylinder pressure falls below 500 psig, the integrity of the zero gas becomes more in question.

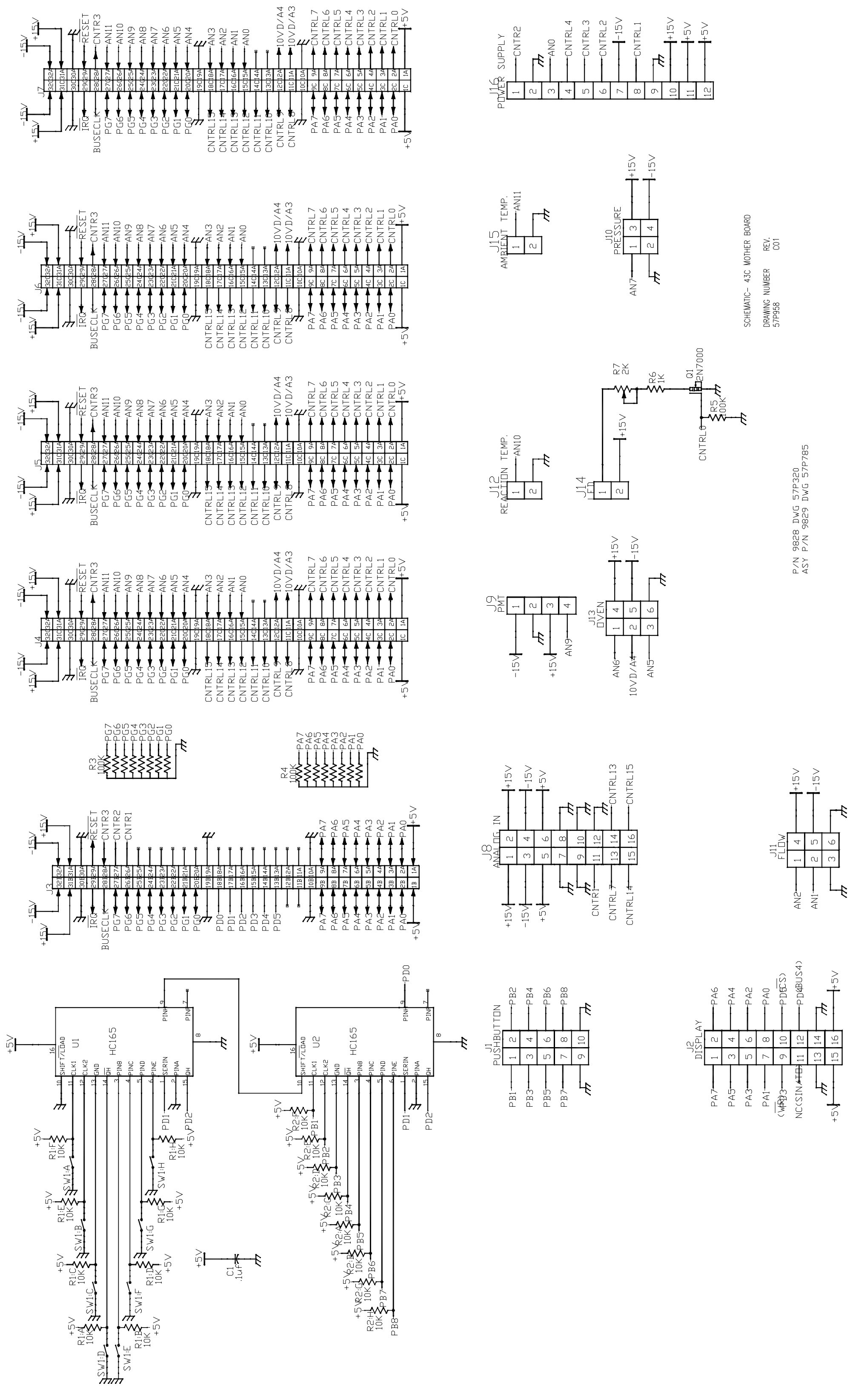
Rather than relying on cylinder sources for zero air, TEI routinely uses zero air generated by “brute force,” that is, by compression, chemical scrubbing and reaction. Ambient air that has been compressed and pressurized to give an output of about 25 psig is dried by passing the air through a heatless air dryer (for example) and then sent through a series of chemical reactors and/or scrubbers. Normally these include indicating silica gel, Purafil, activated charcoal, and a fine (5 micron) particulate filter. When first used, this “brute force” approach actually can generate enhanced impurity levels for NO_x and SO_2, as these gases desorb from the chemical reactors. However after 24 to 48 hours of continuous operation, impurity levels will generally fall and stabilize below detection limits for the Trace Level analyzers. It is critical when using this type of zero air source to always maintain flow through the system. If flow is interrupted, even for a short period, a reconditioning time of up to 24 hours may be required.

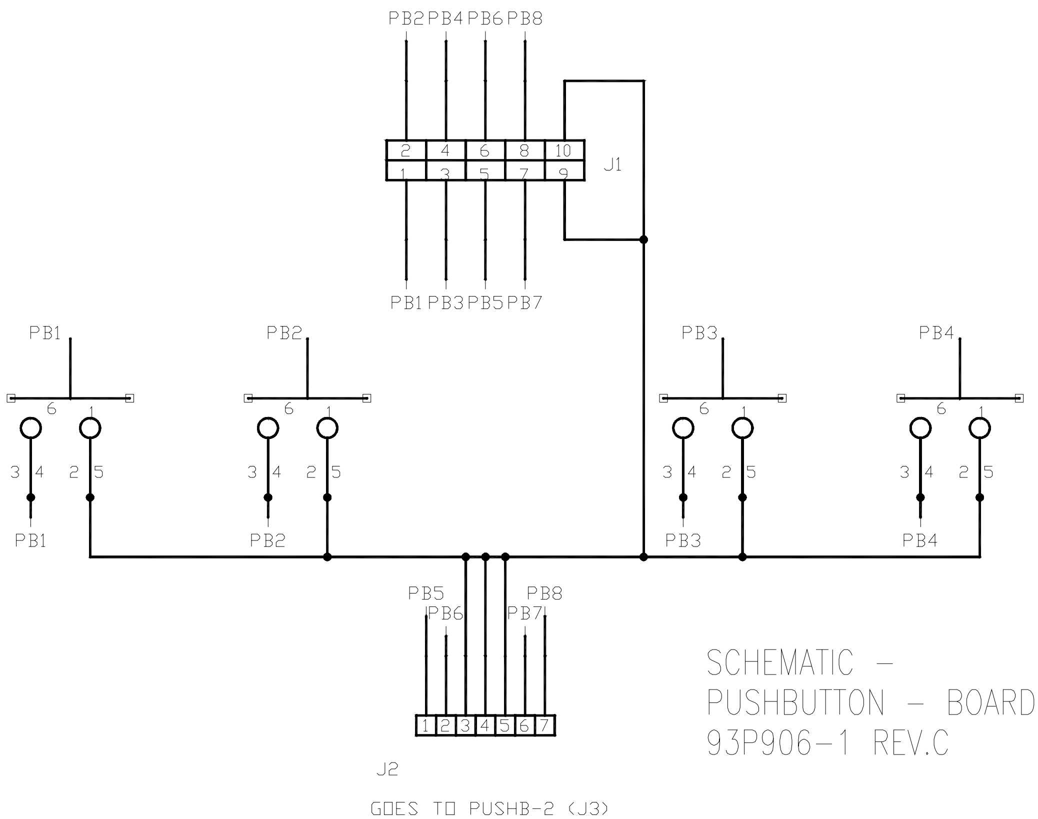
In conclusion, tests by the United States Environmental Protection Agency, Tennessee Valley Authority, Battelle National Labs, and TEI's Engineering Department have demonstrated that Trace Level analyzers are readily calibrated at the low concentration levels required for sub-ambient monitoring. Although extra care is required, primarily in zero air generation, users familiar with normal compliance requirements should be able with minimal additional effort to obtain valid concentration data.

APPENDIX E
SCHEMATICS

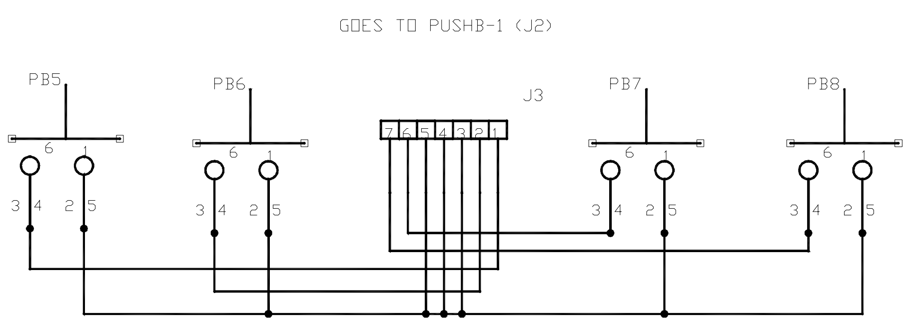
This appendix contains the schematics for the standard and optional printed circuit boards contained in the Model 43C Trace Level. Always turn off the instrument and unplug the power cord before removing any printed circuit board. For more information about appropriate safety precautions, see Chapter 7, "Servicing." A description of each board can be found in Chapter 8, "Theory of Operation."

PC Board	Schematic No.	Part No.	Page
Motherboard	57P958	9829	E-2
Pushbutton Board 1	93P906	9950	E-3
Pushbutton Board 2	93P906	9952	E-3
Processor Board	93P907	9837	E-4
Analog/Digital Board	57P963	8943	E-5
Digital/Analog Board	93P908	9839	E-6
Power Supply Board	57P959	8949	E-7
Trigger Pak	57P908	8392	E-8
Flash Intensity Board	57P905	8755	E-9
Flasher Supply Board	57P967	10996	E-10
Input Board	57P962	8951	E-11
Temperature Control Board	57P903	8765	E-12
C-Link Board	93P914	9843	E-13
4-20 mA Outputs (optional)	93P912	9954	E-14
Input/Output Board (optional)	93P913	9956	E-15
Perm Oven Controller (optional)	57P960	8953	E-16
Rear Connector Interface Board	93P915	9903	E-17

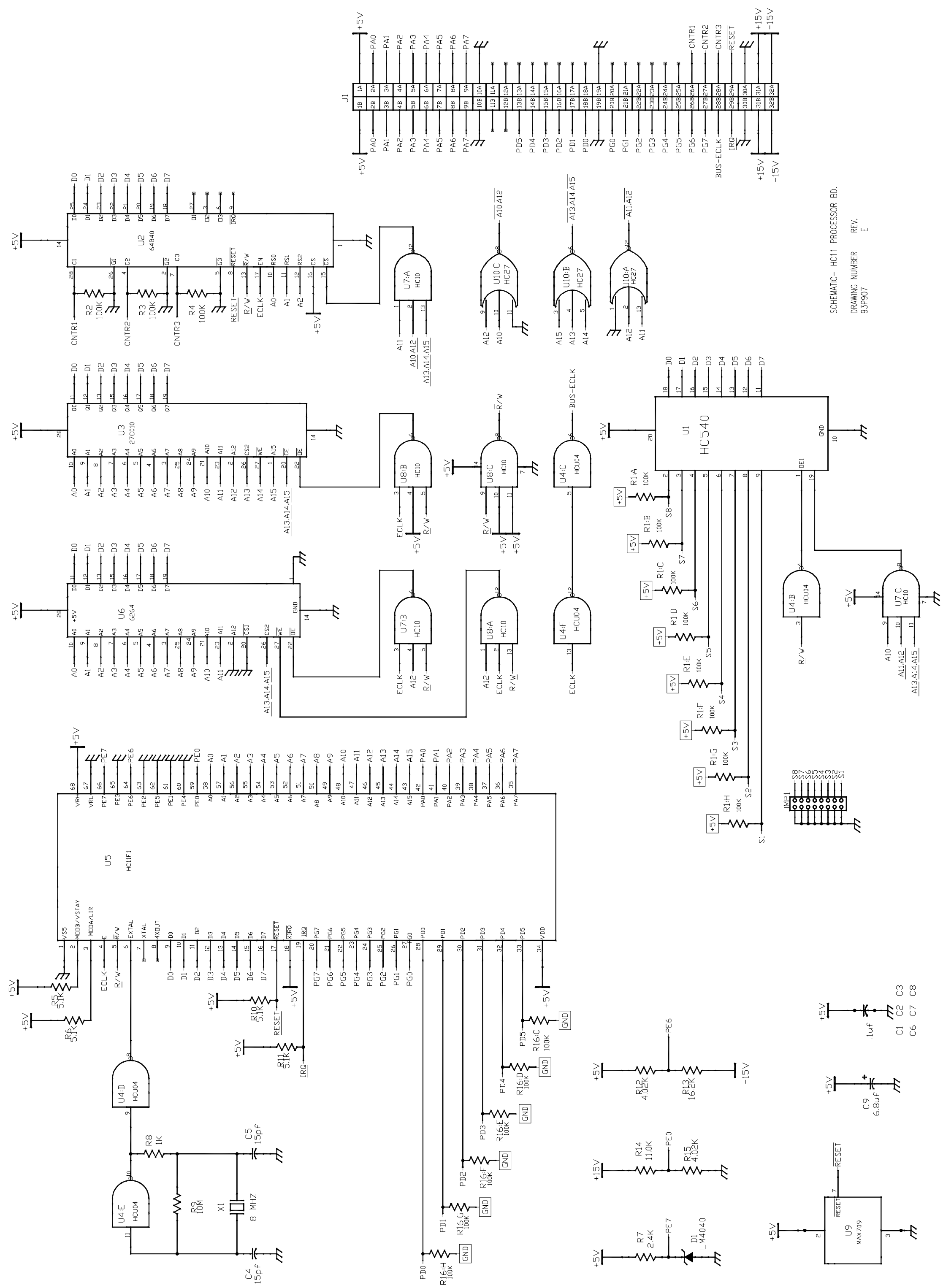

SCHEMATIC- 43C MOTHER BOARD
DRAWING NUMBER 57P958
REV. C01
P/N 9828 DWG 57P320
ASY P/N 9829 DWG 57P785

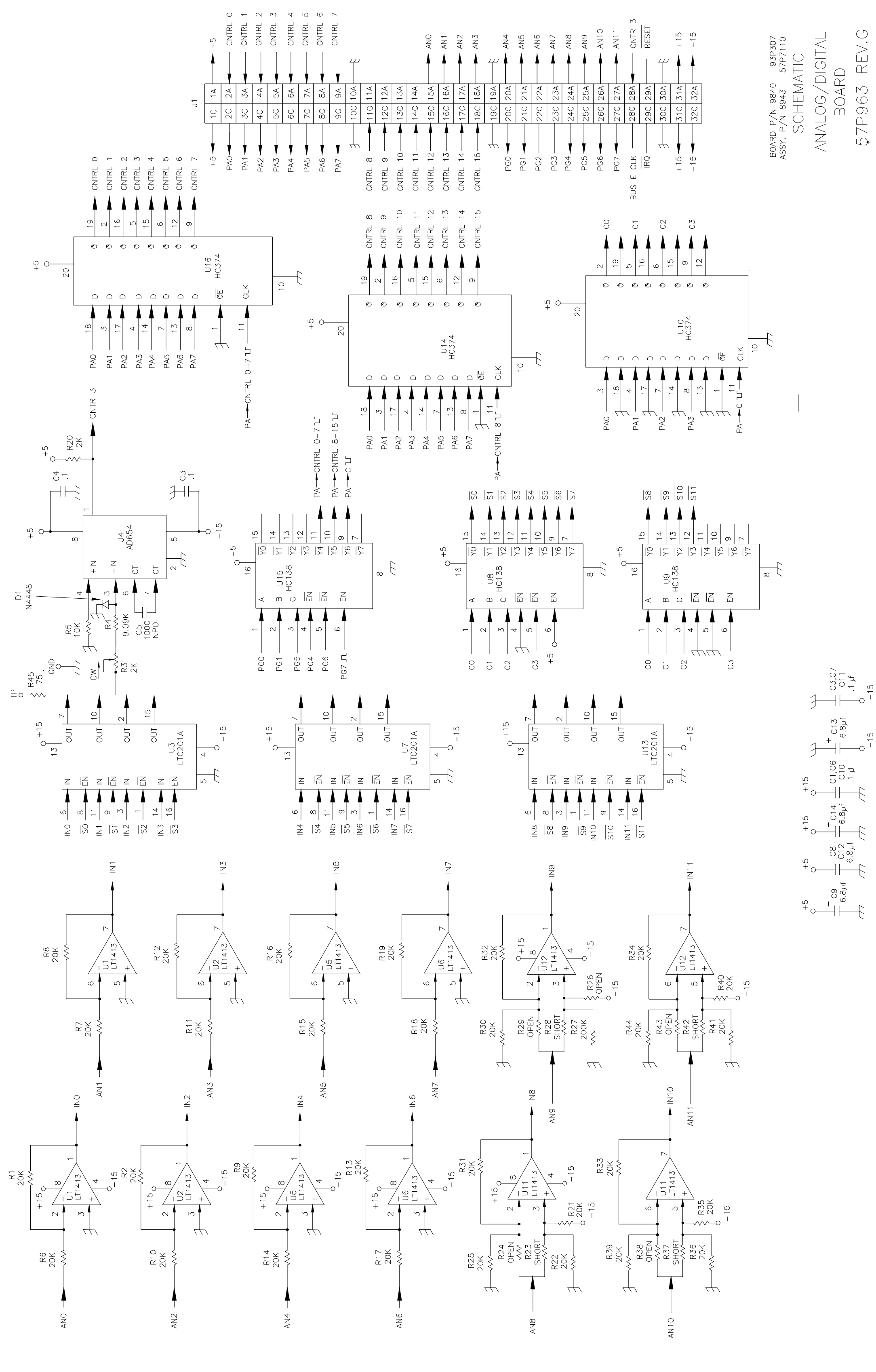


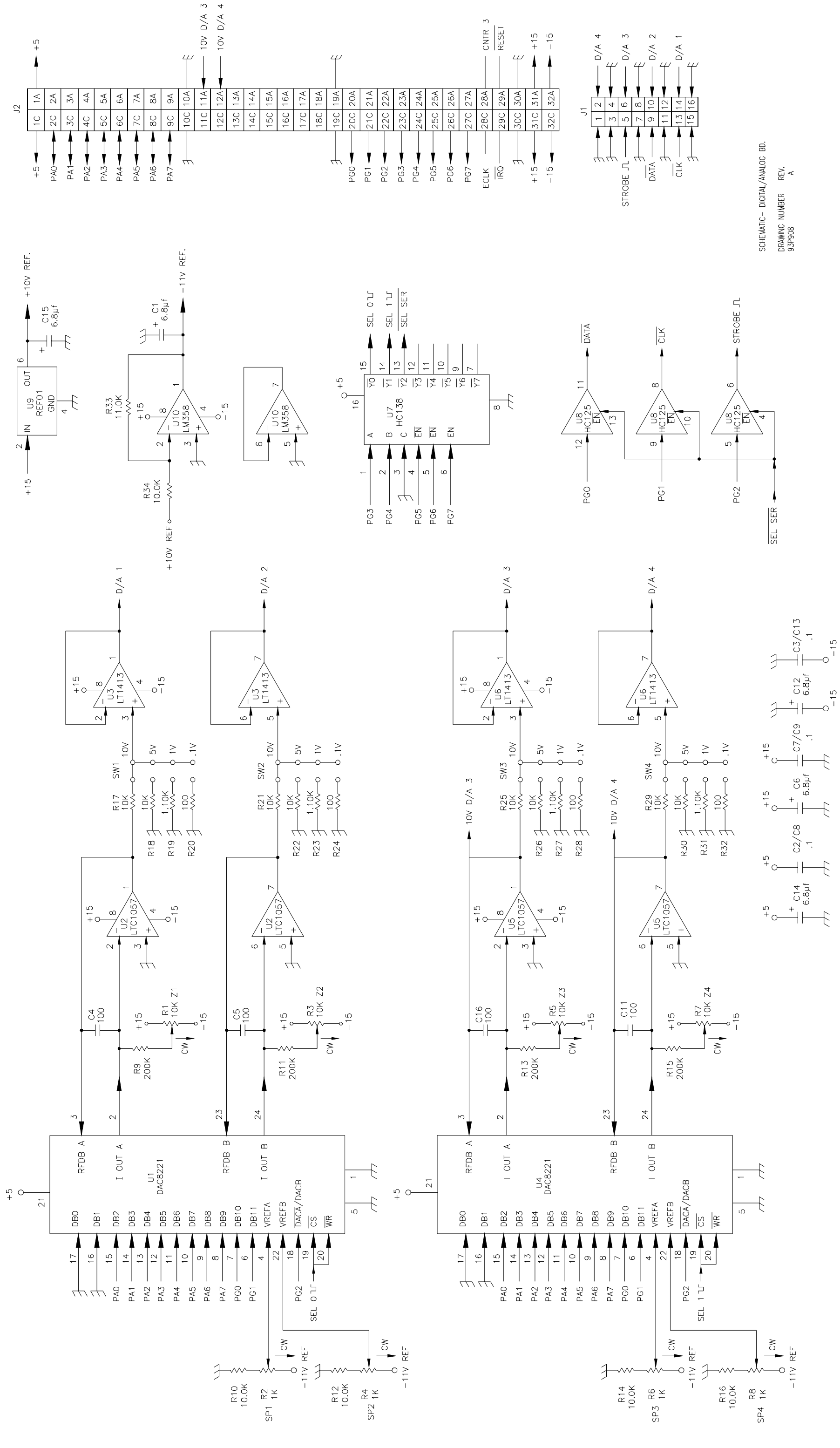
SCHEMATIC –
PUSHBUTTON – BOARD
93P906-1 REV.C

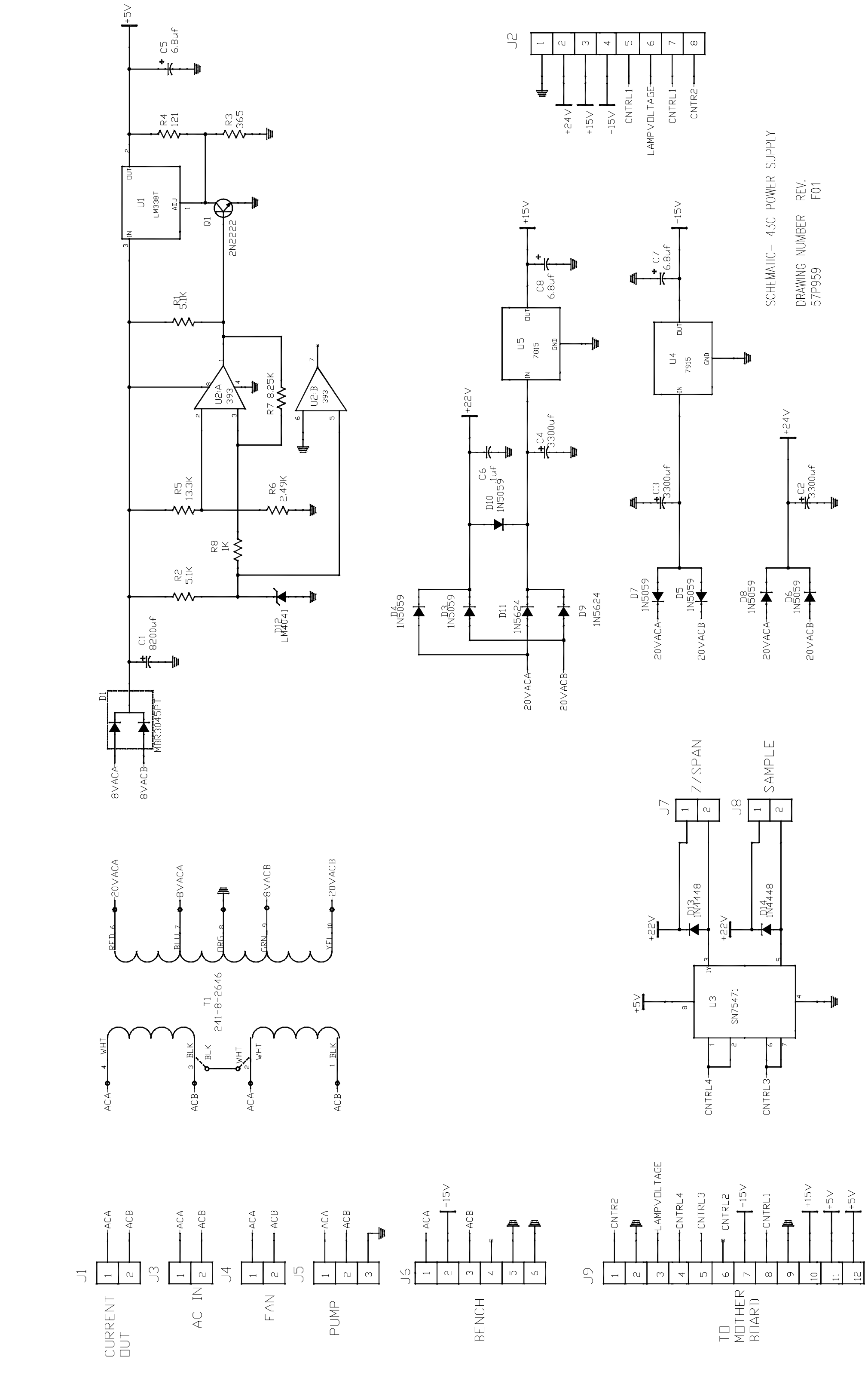


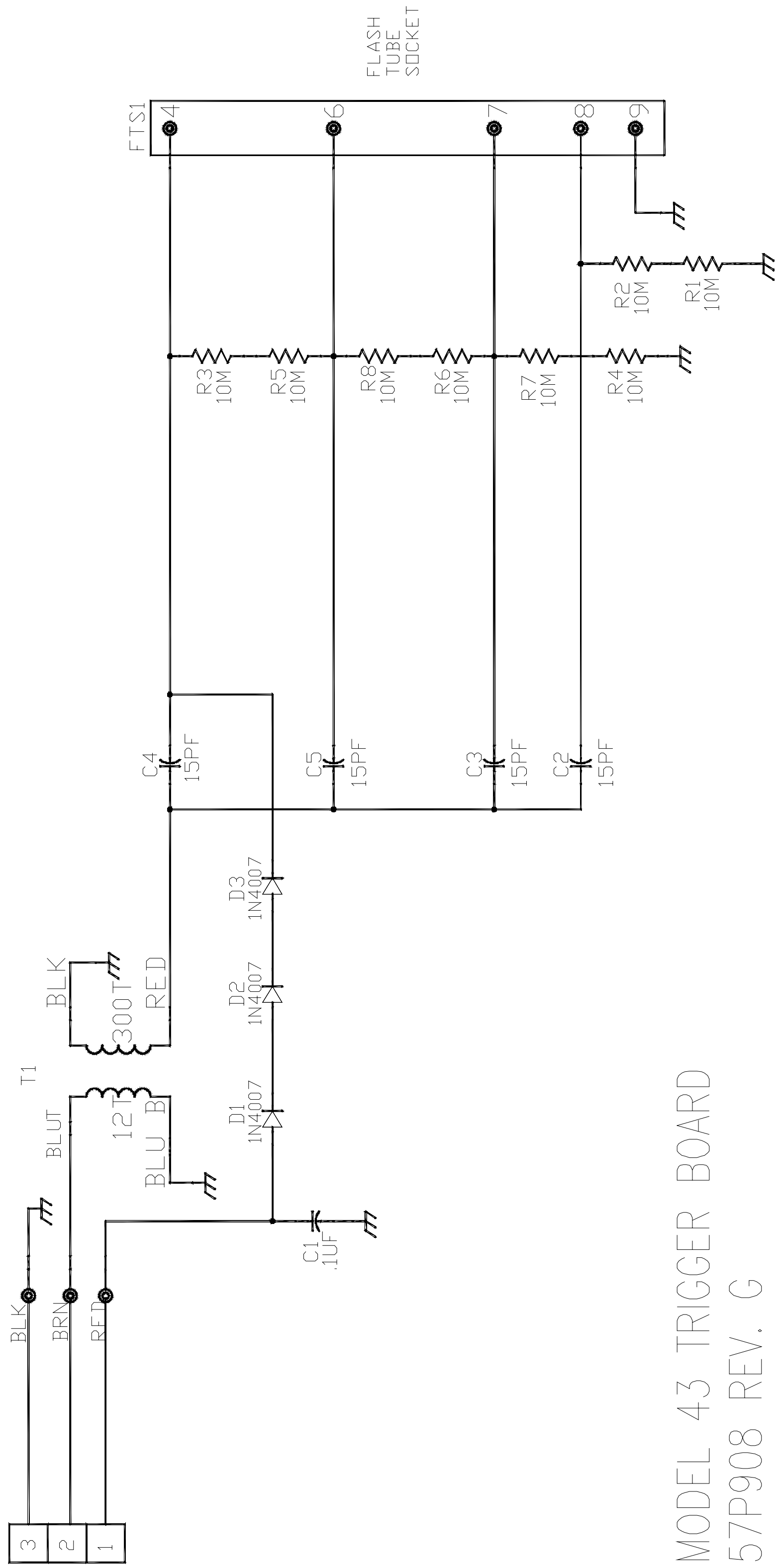
SCHEMATIC –
PUSHBUTTON –2 BOARD
93P906-2 REV.B01

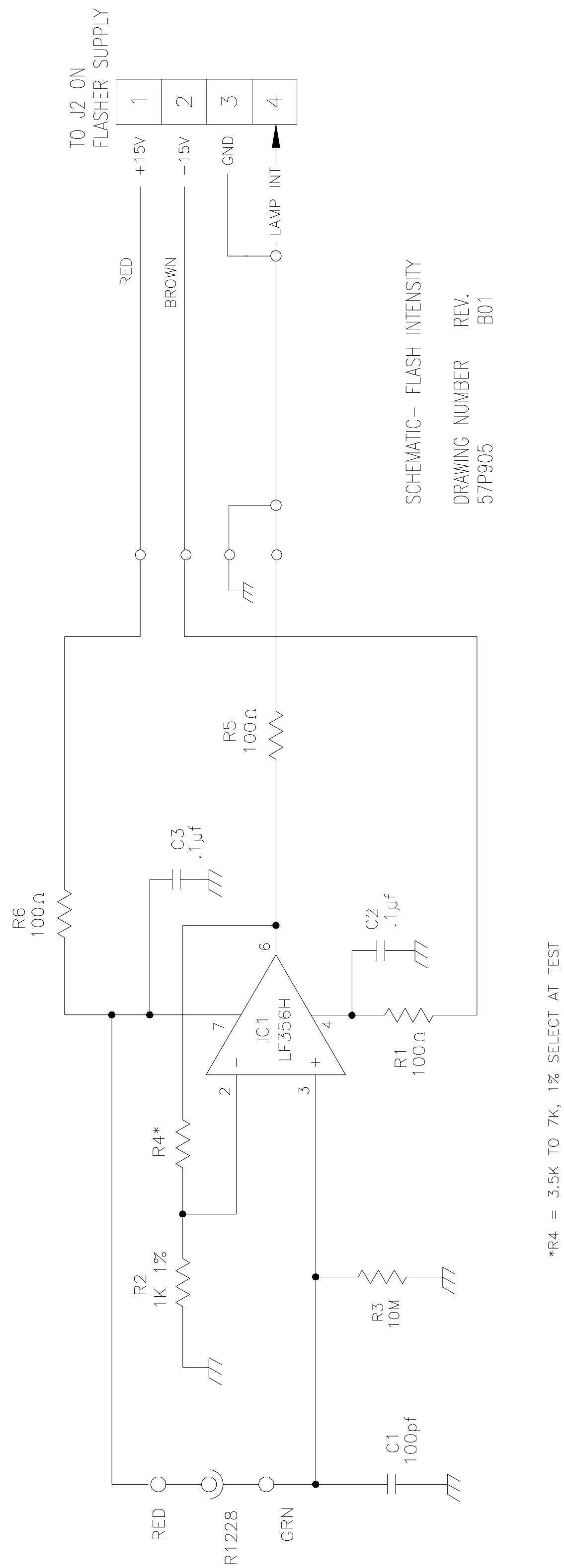

SCHEMATIC- HC11 PROCESSOR BD.
DRAWING NUMBER
93P907
REV.
E

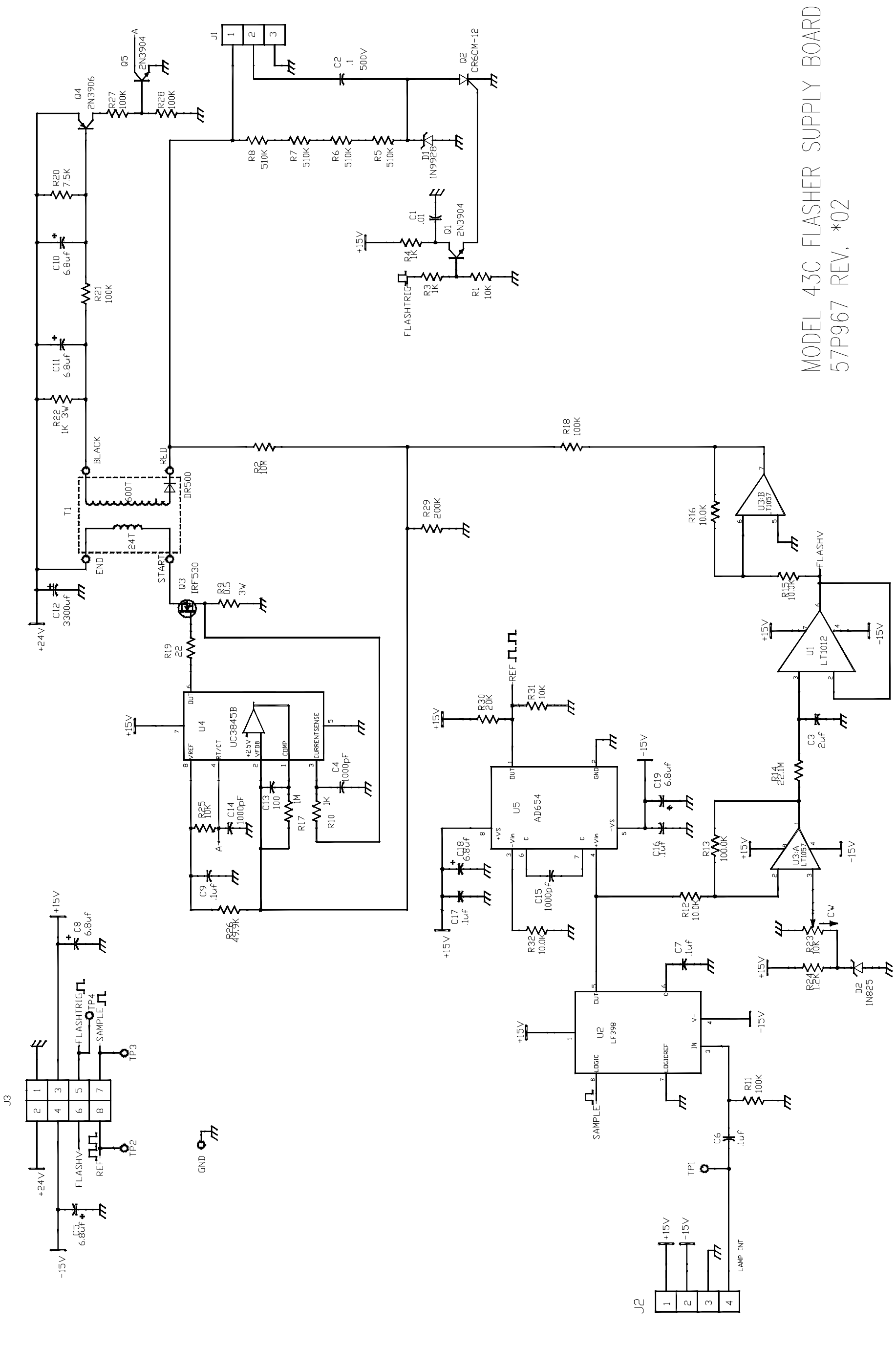

BOARD P/N 9840 93P307
ASSY. P/N 8943 57P7110
SCHEMATIC
ANALOG/DIGITAL
BOARD
57P963 REV.G

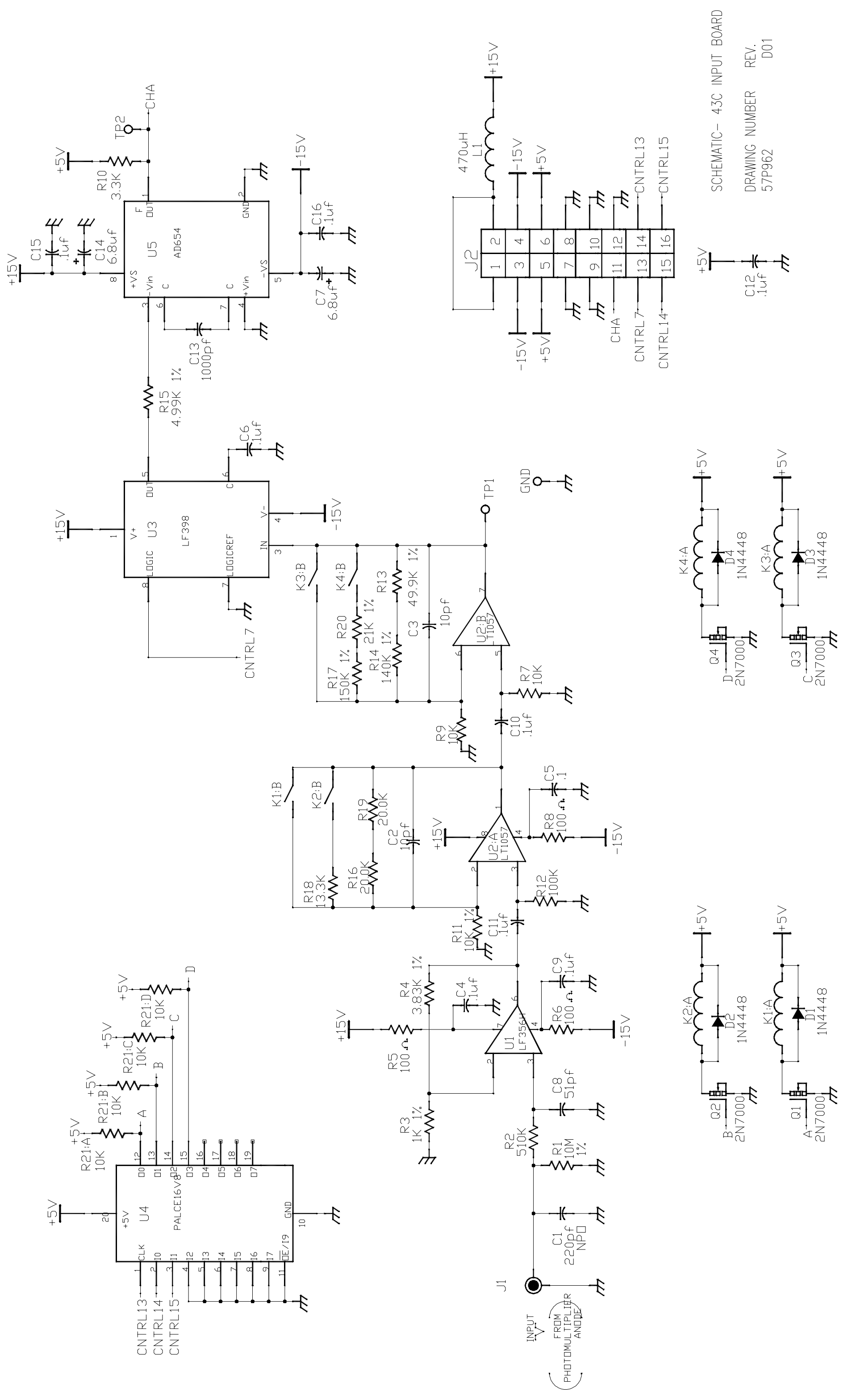

SCHEMATIC- DIGITAL/ANALOG BD.
DRAWING NUMBER 93P908 REV. A

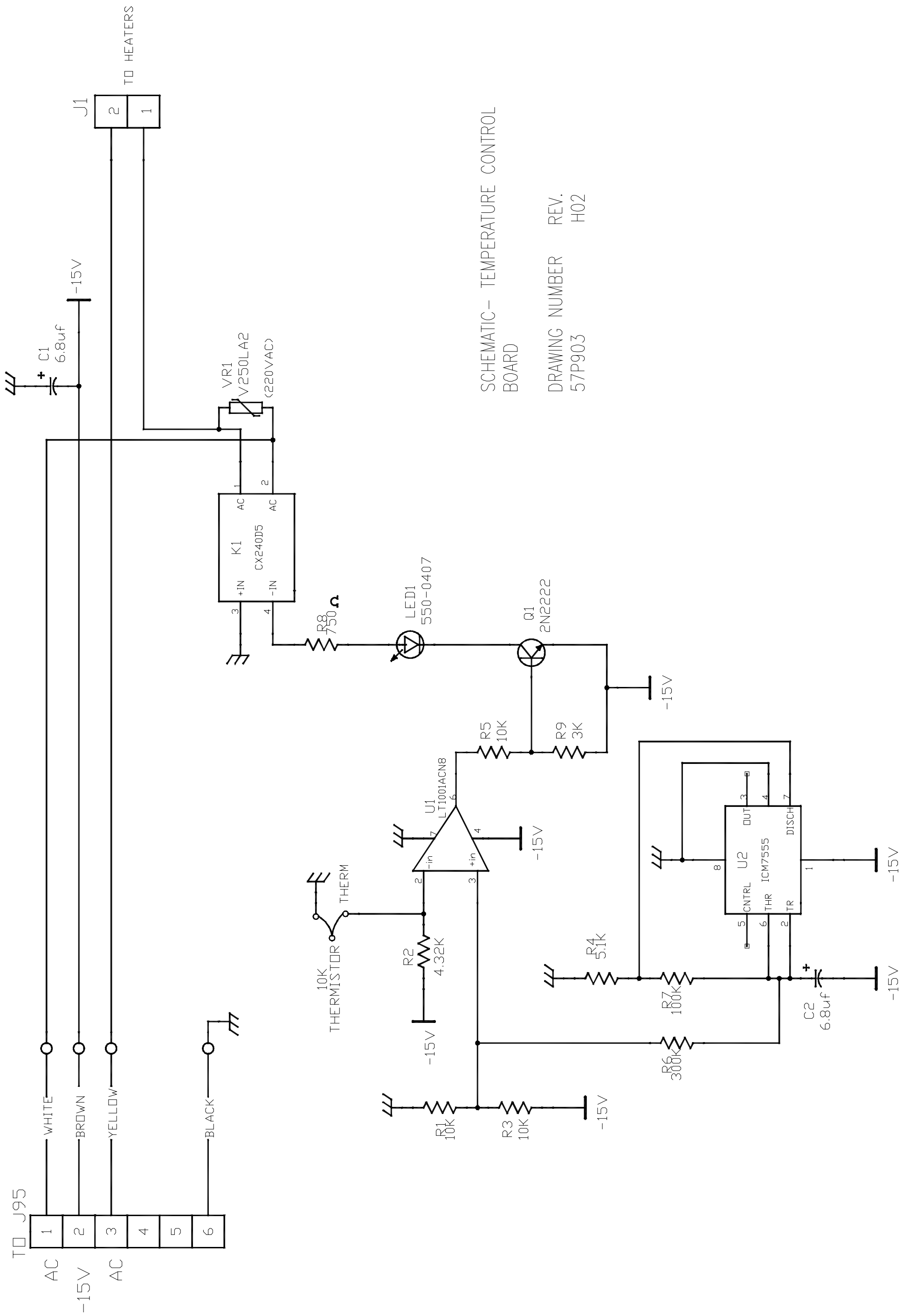

SCHEMATIC- 43C POWER SUPPLY
DRAWING NUMBER REV.
57P959 F01
J1 CURRENT OUT
J3 AC IN
J4 FAN
J5 PUMP
J6 BENCH
J9 TO MOTHER BOARD
J2
J7 Z/SPAN
J8 SAMPLE
T1 241-8-2646
U1 LM338T
Q1 2N2222
U2A 393
U2B 393
U3 SN75471
U4 7915
U5 7815
D1 MBR3045PT
D12 LM4041
C1 8200uf
C2 3300uf
C3 3300uf
C4 3300uf
C5 6.8uf
C6 1uf
C7 6.8uf
C8 6.8uf
R1 5.1K
R2 5.1K
R3 365
R4 121
R5 13.3K
R6 2.49K
R7 8.25K
R8 1K
D13 1N4448
D14 1N4448
+5V
+15V
-15V
+22V
+24V
CNTRL1
CNTRL2
CNTRL3
CNTRL4
CNTR2
LAMPVOLTAGE
20VACA
20VACB
8VACA
8VACB
ACA
ACB


FLASH TUBE SOCKET
FTS1
4
6
7
8
9
R2 10M
R1 10M
R3 10M
R5 10M
R8 10M
R6 10M
R7 10M
R4 10M
C4 15PF
C5 15PF
C3 15PF
C2 15PF
D3 1N4007
D2 1N4007
D1 1N4007
BLK
300T
RED
T1
BLUT
12T
BLU B
C1 .1UF
BLK
BRN
RED
3
2
1
MODEL 43 TRIGGER BOARD
57P908 REV. G

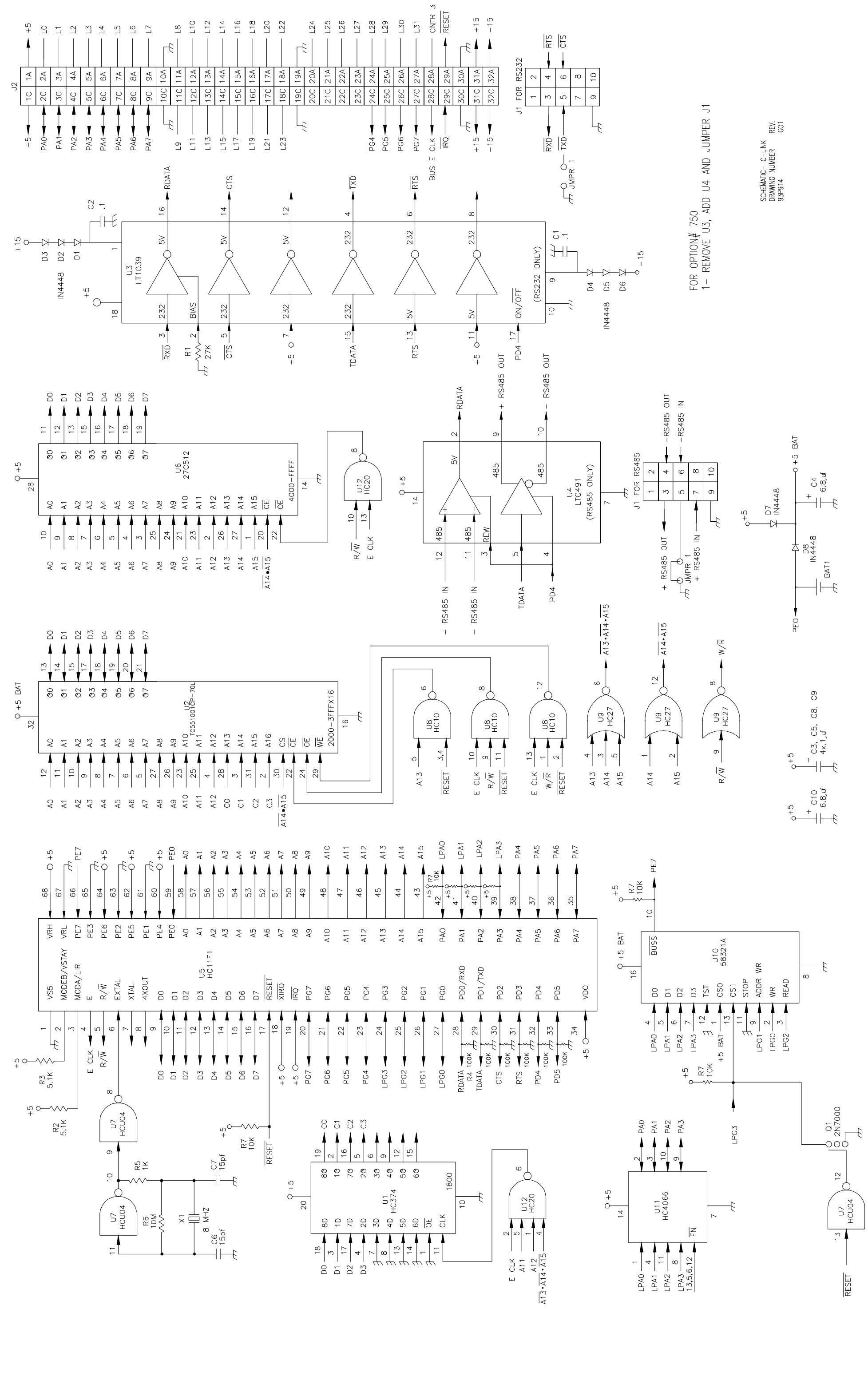

TO J2 ON
FLASHER SUPPLY
1
2
3
4
+15V
-15V
GND
LAMP INT
RED
BROWN
SCHEMATIC- FLASH INTENSITY
DRAWING NUMBER
57P905
REV.
B01
R5
100Ω
R6
100Ω
C3
.1µf
C2
.1µf
IC1
LF356H
7
6
4
2
3
R1
100Ω
R4*
R2
1K 1%
R3
10M
C1
100pf
RED
R1228
GRN
*R4 = 3.5K TO 7K, 1% SELECT AT TEST

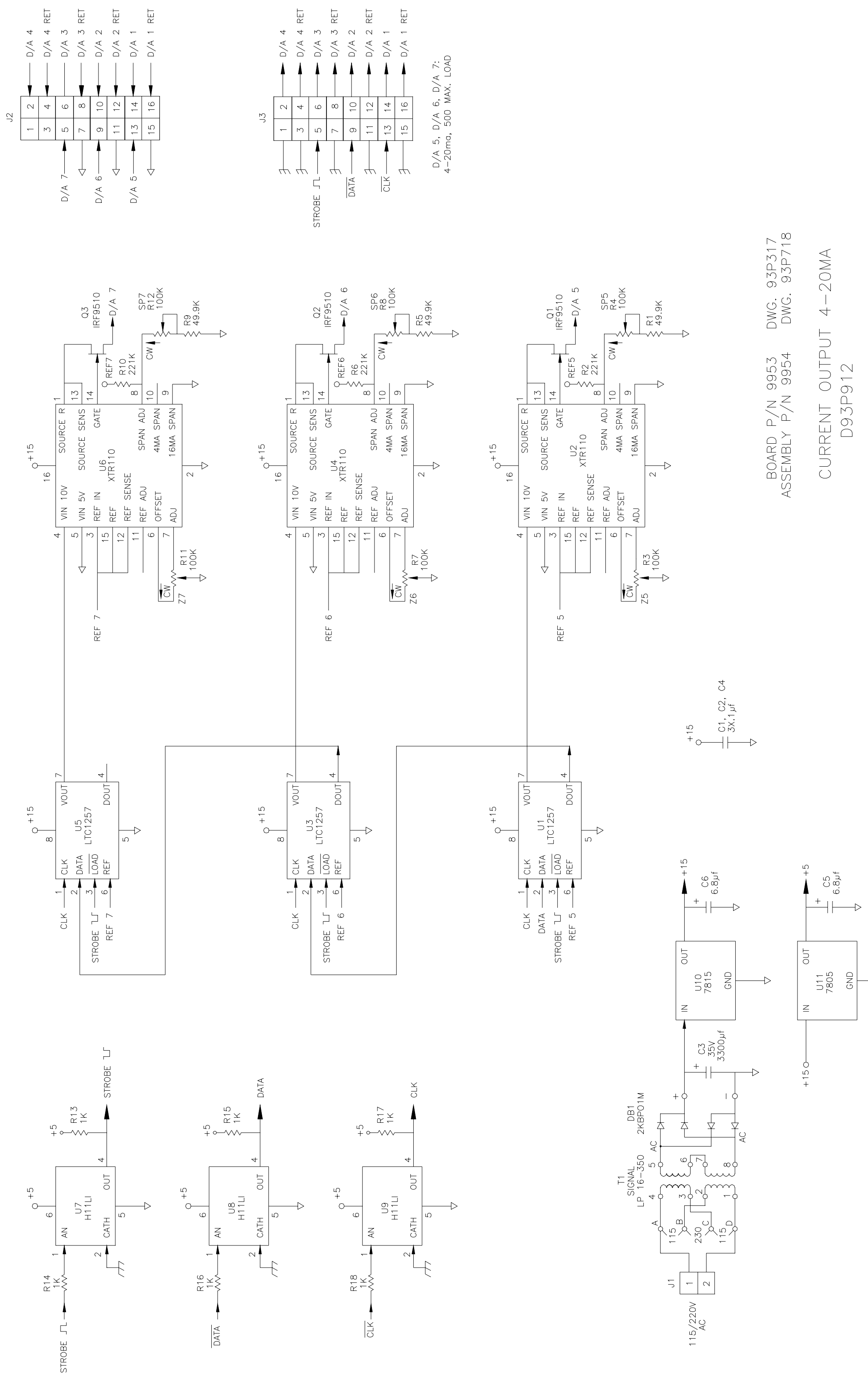

MODEL 43C FLASHER SUPPLY BOARD
57P967 REV. *02

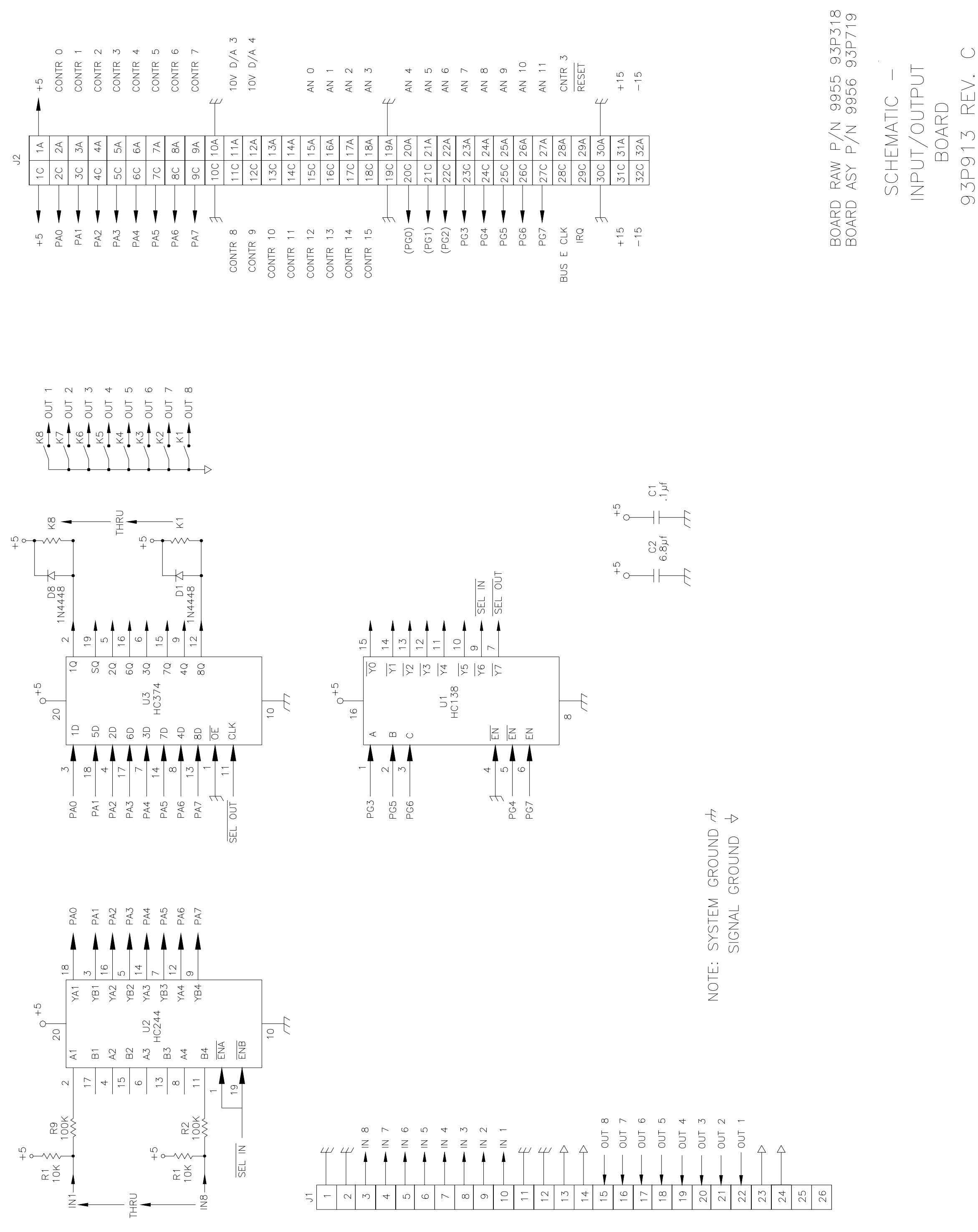

SCHEMATIC- 43C INPUT BOARD
DRAWING NUMBER 57P962
REV. D01

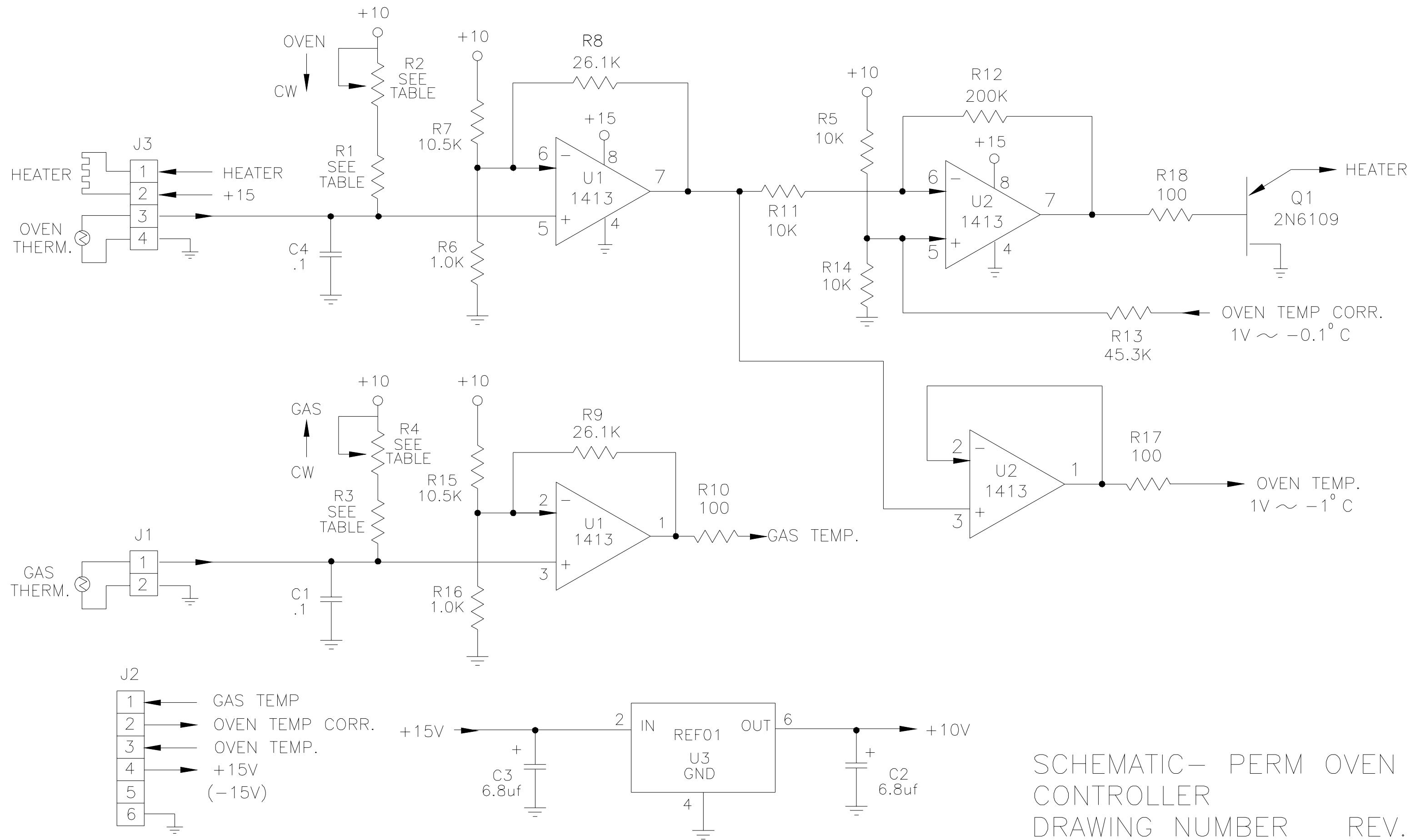


SCHEMATIC- TEMPERATURE CONTROL BOARD
DRAWING NUMBER 57P903
REV. H02
TO HEATERS
J1
TO J95
AC
-15V
AC
WHITE
BROWN
YELLOW
BLACK
C1 6.8uf
-15V
VR1 V250LA2 (220VAC)
K1 CX240D5
+IN
-IN
AC
R8 750 Ω
LED1 550-0407
Q1 2N2222
R5 10K
R9 3K
U1 LT1001ACN8
THERM
10K THERMISTOR
R2 4.32K
R1 10K
R3 10K
R6 300K
R7 100K
R4 5.1K
C2 6.8uf
U2 ICM7555
CNTRL
THR
TR
OUT
DISCH


FOR OPTION# 750
1- REMOVE U3, ADD U4 AND JUMPER J1
SCHEMATIC- C-LINK
DRAWING NUMBER 93P914
REV. G01


BOARD P/N 9953 DWG. 93P317
ASSEMBLY P/N 9954 DWG. 93P718
CURRENT OUTPUT 4-20MA
D93P912
D/A 5, D/A 6, D/A 7:
4-20ma, 500 MAX. LOAD

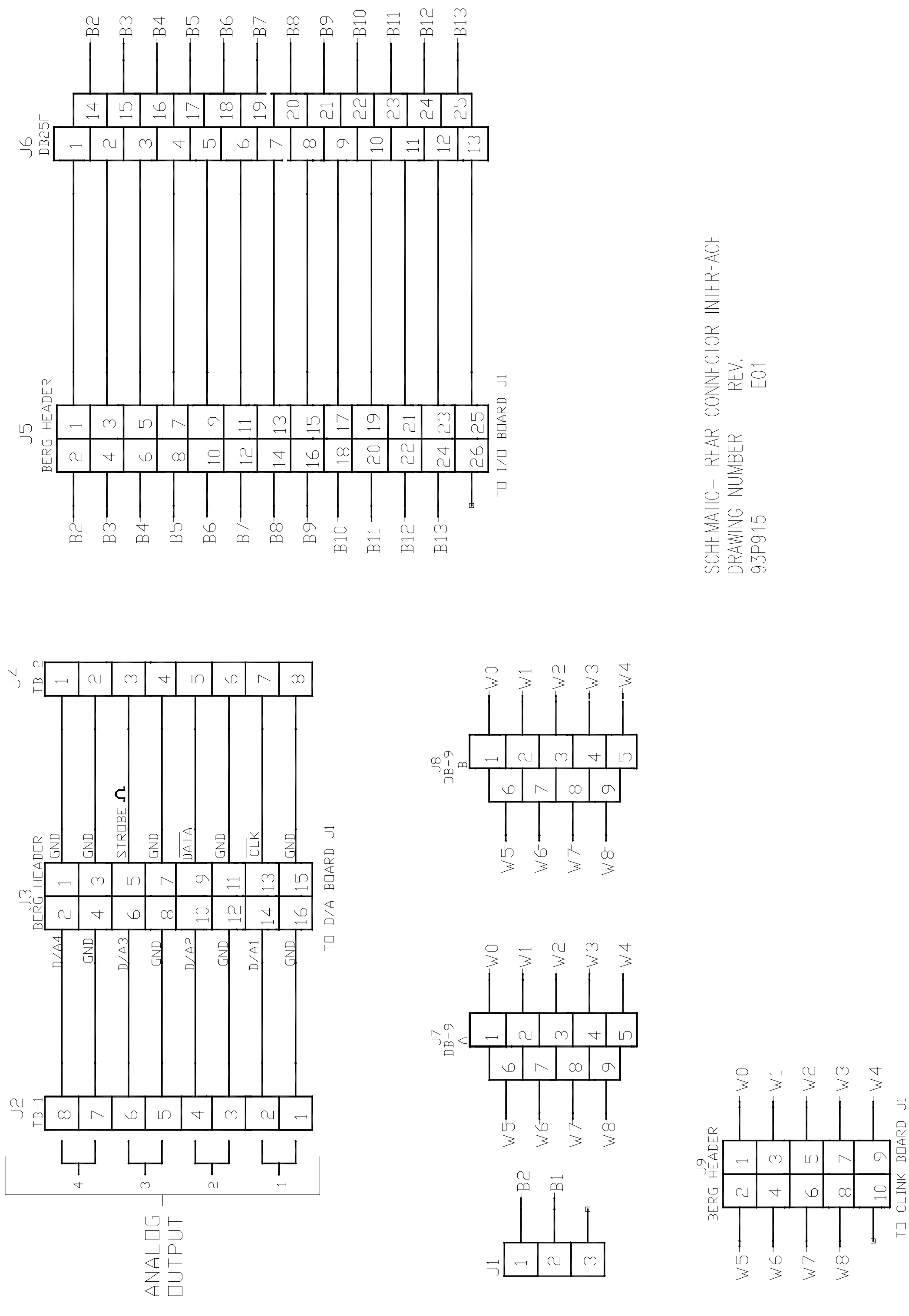

BOARD RAW P/N 9955 93P318
BOARD ASY P/N 9956 93P719
SCHEMATIC – INPUT/OUTPUT BOARD
93P913 REV. C
NOTE: SYSTEM GROUND
SIGNAL GROUND
U2 HC244
U3 HC374
U1 HC138
J1
J2



SCHEMATIC- PERM OVEN CONTROLLER

DRAWING NUMBER 57P960 REV. E

RESISTOR TABLE:
FOR 30.0°C TEMP. R1 AND R3 = 69.8k(1/4W 1% P/N 49985)
FOR 35.0°C TEMP. R1 AND R3 = 56.2K
FOR 45.0°C TEMP. R1 AND R3 = 38.3K
FRO 30.0°C TEMP, REPLACE R2 & R4 ONLY, WITH A 5K POT(M146C ONLY)


SCHEMATIC- REAR CONNECTOR INTERFACE
DRAWING NUMBER REV.
93P915 E01
J6
DB25F
J5
BERG HEADER
TO I/O BOARD J1
J4
TB-2
J3
BERG HEADER
TO D/A BOARD J1
STROBE
DATA
CLK
GND
D/A4
D/A3
D/A2
D/A1
J2
TB-1
ANALOG OUTPUT
J8
DB-9
B
J7
DB-9
A
J1
J9
BERG HEADER
TO CLINK BOARD J1

APPENDIX F

PUMP MAINTENANCE

Thermo Environmental Instruments

8 West Forge Parkway
Franklin, MA 02038
(508) 520-0430
Fax: (508) 520-1460
Telex: 200205 THEMO UR

Operating and Maintenance Instructions

Diaphragm Vacuum Pump Models: 8550, 8551, 8706

Operating Instructions

Note: The following guidelines should be observed to promote safe and reliable operation of your TEI pump.

1. TEI units are all 100% oil-free. No maintenance at all is necessary for the bearings and NO lubrication should be done. All bearings are sealed and permanently lubricated. For repair service, call TEI Customer Service.
2. Be sure that the available electric power matches specifications marked on the motor. Serious damage may occur to the motor if connected to an improper voltage. All TEI units should be grounded using the provided brass screw. In the event of an electrical short circuit, grounding reduces the risk of electric shock by providing an escape wire for the electric current.
3. The pump should be placed where the surrounding temperature remains between 40°F and 104°F (5°C and 41°C). This is particularly important when the unit is installed in a confined space where heat may build up during operation.
4. Standard models are designed to *start against atmospheric pressure only, not under load (Pressure or vacuum).* Care must be taken to eliminate load when pump is turned off for any reason.
5. Use this pump only to pump air or gas, not liquids or particulates. *Damage to the pump or loss of performance can occur if liquids or particulates enter the system.* In the event that corrosive gases are to be pumped, be certain that a corrosion-resistant model is used. *The life of the pump can be prolonged if the formation of condensate within the pump is avoided.*
6. Always install the pump in such a location that it is protected from direct (or indirect) moisture contact.
7. Avoid operating the pump in very dusty conditions. If this cannot be prevented, then be sure to install an inlet filter and inspect and change it frequently.
8. If flow is throttled or restricted for any reason, care must be taken to avoid exceeding the maximum continuous operating design pressure of the unit.
9. Be sure that the pump is installed at the highest point within the system to prevent possible condensate from entering the unit.
10. Please remove any protective plastic plugs supplied in the intake or outlet ports of your pump prior to applying power to the motor.

Troubleshooting

WARNING! AC motors are thermally protected and will automatically restart unexpectedly when the overload device resets. Don't pump flammable or explosive gases or operate this pump in an atmosphere containing flammable or explosive gases.

Your TEI Pump should perform to specifications for years if the simple operating instructions and precautions are observed .

If you experience a problem and suspect the pump, try these simple checks prior to calling for assistance:

1. Check that all system interconnections are gas-tight.
2. Remove the head assembly as described in "Changing the Diaphragm and Valves". Look for any foreign matter; usually bits of Teflon® tape or particulates carried into the valving system or crystallized material from previously pumped vapors. All of the above must be cleared out and the pump reassembled with clean parts.
3. If pitting of the pump parts or tearing of the diaphragm is observed, it is possible that the gas/vapor being pumped is capable of attacking the wetted parts of the pump.

Chemical resistance charts should be consulted if you are in doubt. Generally, replacing the diaphragm and valves will restore the pump to operating specifications if the valve plate is not pitted in the valve seat area.

Limited Warranty

THERMO ENVIRONMENTAL INSTRUMENTS, INC. (TEI) warrants to buyer that its products will be free from defects in material and workmanship under normal and appropriate use, and agrees to repair or replace any of its products without charge for parts or labor within one year from the date of shipment to the original purchaser.

Products to be evaluated for warranty coverage:

Determination of coverage under this warranty is the sole responsibility of the manufacturing engineering representative of TEI. This determination will frequently require the return of the product to TEI. All product returns will be handled in accordance with TEI's product return policy. TEI reserves the right to inspect custom installations and devices that use TEI products as part of the warranty evaluation process. This warranty does not cover any misuse, negligence, deterioration by chemical action, unauthorized repair or alteration in any way, inappropriate handling or storage that in our judgement caused the product failure. TEI shall not be liable for any inconvenience, loss of use, or any consequential loss, damage or injury arising from any cause whatsoever. No employee, agent or representative of TEI shall have any right or authority to vary or alter the terms of this warranty. This warranty gives you specific legal rights, and you may have other rights which vary from state to state.

Important Note

TEI offers engineering and technical assistance to support the application and selection of our products. We strongly suggest that you ensure that the product you have purchased from us is suitable for the use that you intend; we cannot be responsible for any problems or inconveniences that result from the incorrect application or use of our products. If you provide enough information to us, we will work with you to optimize the performance of our products in your application.

Please call our Technical Sales Department for further information.

Return Requests / Inquiries

Direct all warranty and repair requests to TEI Customer Service Department for instructions before returning any unit for repair or evaluation. We will fax you a "Return Instruction Sheet" for guidance on the proper marking, packing and documentation requirements.

Important information conforming to the "Right To Know" act, such as a Material Safety Data Sheet may be required.

Products shipped to TEI must have a Return Materials Authorization Number (RMA) file number marked on the outside of the package, otherwise they will be refused by our receiving department.

Spare Parts Kits

For TEI Pump 8550
115V/60Hz
Kit Part Number: 8606

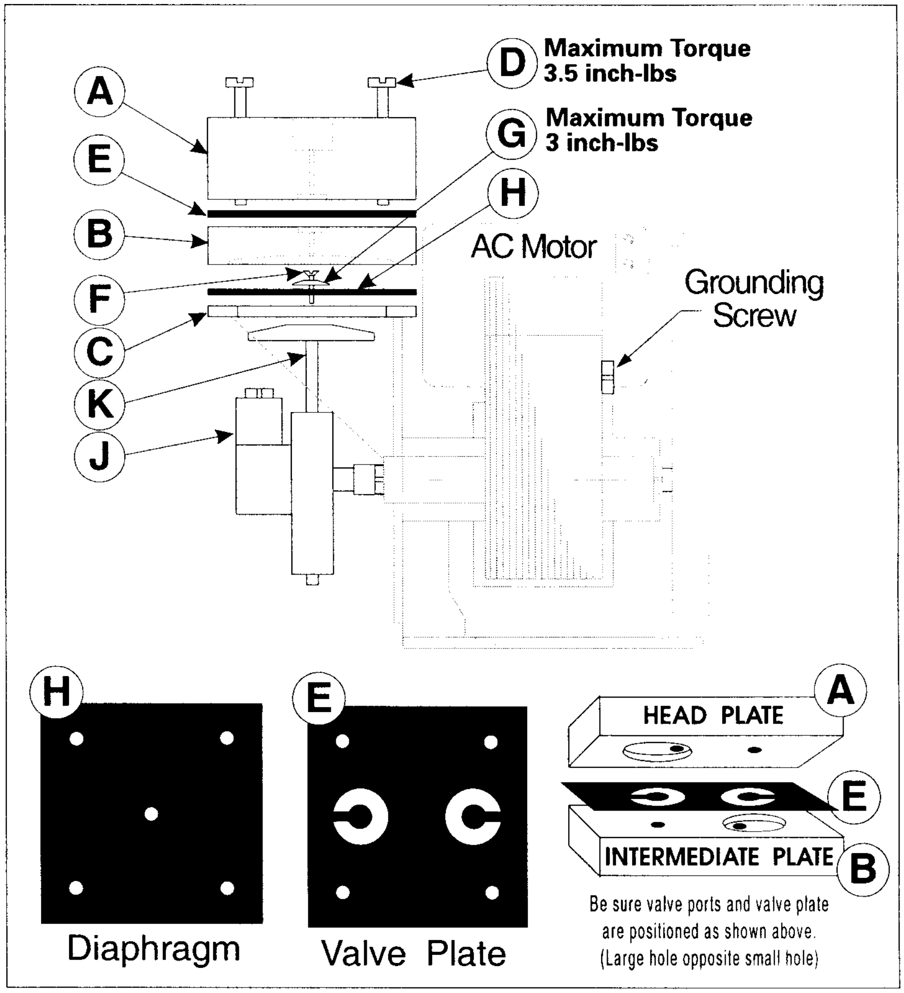
For TEI Pump 8551
220/240V/50/60Hz
Kit Part Number: 8606

For TEI Pump 8706
110V/50-60Hz 220V/50-60Hz
Kit Part Number: 8606

Changing the Diaphragm and Valve Plate

During normal use, the diaphragm and valve plate are the only parts of the pump that need to be replaced. Changing them is a simple process when the following steps are taken.

If you run into a problem or have a question regarding the following procedure, please call the TEI Service Department for assistance.



Materials/Tools needed:
The proper replacement kit(s)
Marking Pencil
Slotted-head screwdriver

1. Disconnect the pump from electrical power.
2. Mark the relative positions of the head plate **A** intermediate plate **B** and crankcase housing **C** with a line using a marker for ease of reassembly later.
3. Undo the 4 slotted-head cap screws **D** and lift off the head plate **A,** valve plate **E** and intermediate plate **B**.
4. Lightly clean the valve seat area of the head plate **A** and intermediate plate **B** of any debris or deposits with fine steel wool. This area must be clean and smooth, without pits or scratches.
5. Loosen the countersunk clamping disc screw **F** and remove the clamping disc **G**, and the diaphragm **H**.
6. Turn the counterweight **J** until the connecting rod **K** is at mid–stroke, and place the new diaphragm **H** (Teflon (white) side up on AT or ST models) on the housing **C,** lining it up with the screw holes.
7. Place the clamping disc **G** (bevel side up).on top of the new diaphragm **H**. **T**ighten the assembly using the countersunk clamping disc screw **F** to a maximum torque of 3 inch-lbs.
   DO NOT OVERTIGHTEN!
8. Place the intermediate plate **B** over the diaphragm, lining up the marks made previously in step 2.
9. Place the valve plate **E** on top of the intermediate plate **B**, orienting the valve flaps with the holes. There is no top or bottom of the valve plate.
10. Place the head plate **A** on top of the valve plate **E**, lining it up with the markings you made in step 2. Note orientation of the valve ports in the diagram
11. Be sure that all components are centered, then tighten the 4 slotted-head cap screws **C** uniformly to a maximum torque of 3.5 inch-lbs. in a criss-cross pattern. **DO NOT OVERTIGHTEN!**
12. Check that the pump runs freely by turning the counterweight **J** by hand. Check all mechanical and electrical connections for tightness.
13. Apply power to the pump. Listen for a possible "knocking sound." If it is present, equally loosen the four head screws slightly until the sound just disappears. This step is to be sure that the clamping disc does not touch the intermediate plate during operation.

Please Note:
Excessive tightening of the clamping disc screw and the four head screws will cause premature wear on the diaphragm and bearings and must be avoided. Observe stated torque specifications.

For service or parts CONTACT:

Thermo Environmental Instruments
8 West Forge Parkway
Franklin, MA 02038
(508) 520-0430
Fax: (508) 520-1460
Telex: 200205 THEMO UR

(0699)